THE ENGINEER

A Seven-Day Journal

The New Government

Following the result of the general election, which took place on October 25th, Mr. C. R. Attlee was received by the King on Friday evening last and tendered his resignation as Prime Minister and First Lord of the Treasury, which His Majesty was graciously pleased to accept. The King then sent for Mr. Winston Churchill and requested him to form a new administration. Some of the new Cabinet appointments were announced on Saturday and the remainder on Tuesday evening. The new Cabinet has sixteen members—one less than in the previous administration—and is constituted as follows: Prime Minister and Minister of Defence, Mr. Winston Churchill; Foreign Secretary, Mr. Anthony Eden; Lord President of the Council, Lord Woolton; Lord Privy Seal, The Marquess of Salisbury; Lord Chancellor, Lord Simonds; Home Secretary and Minister for Welsh Affairs, Sir David Maxwell Fyfe, K.C.; Chancellor of the Exchequer, Mr. R. A. Butler; Secretary of State for Commonwealth Relations, Lord Ismay; Secretary of State for the Colonies, Mr. Oliver Lyttelton; Secretary of State for Scotland, Mr. James Stuart; Secretary of State for Co-ordination of Transport, Fuel and Power, Lord Leathers; Minister of Health, Captain H. F. C. Crookshank; Minister of Labour and National Service, Sir Walter Monckton, K.C.; Minister of Housing and Local Government, Mr. Harold Macmillan; President of the Board of Trade, Mr. Peter Thorneycroft; Paymaster-General, Lord Cherwell.

Director of Mechanical Engineering Research

The Department of Scientific and Industrial Research has announced this week the appointment of Dr. D. G. Sopwith, M.I.Mech.E., as Director of Mechanical Engineering Research, in succession to the late Dr. G. A. Hankins. Until recently, Dr. Sopwith was superintendent of the engineering division of the National Physical Laboratory, and since the death of Dr. Hankins in November last, he has been acting Director of Mechanical Engineering Research, taking charge of the Mechanical Engineering Research Organisation's laboratories at East Kilbride, Scotland. Dr. Sopwith, who is forty-five, was born in London and was educated at Manchester Grammar School and Manchester University, where he obtained a Whitworth Scholarship and graduated with first-class honours in mechanical engineering in 1928. He joined the staff of the engineering division of the National Physical Laboratory immediately, and succeeded to the position of superintendent of the division in 1948. Dr. Sopwith has published many technical papers on a wide range of subjects, including the design and causes of failures of engineering components; chains and lifting gear; fatigue; helical compression springs; screw threads, and the penetration of armour plate and breech mechanisms.

The Late Sir Henry Grayson, Bt.

It is with regret that we announce the death of Sir Henry Mulleneux Grayson, Bt., which occurred at his home, Orchard Court, London, W.1, on Saturday last, October 27th. Sir Henry, who was in his eighty-seventh year, had retired from the chairmanship of Grayson, Rolls and Clover Docks, Ltd., in September, when he was succeeded by his son, Mr. Denys Grayson. Sir Henry was born in Liverpool on June 26, 1865, and was educated at Winchester. He then served an apprenticeship with a Liverpool shipbuilding firm, followed by some consultant experience, before joining the company which he served as chairman since 1904. He was a director of several shipping and shipbuilding companies and during the first world war was honorary director of ship repairs at the Admiralty and a member of the shipbuilders advisory committee to the Admiralty. After the war he represented Birkenhead West in the House of Commons from 1918 to 1922; Sir Henry was made a C.B.E. in 1920 and a K.B.E. in the same year. Two years later he was created a baronet. He was also a Commander of the Order of Leopold II and an Officier Legion d'Honneur. During his lifetime Sir Henry served on a number of committees, and at the time of his death he was a Liveryman of the Worshipful Company of Shipwrights, a Freeman of the City of Liverpool by birthright, and one of the oldest members of the Institution of Naval Architects, having been elected in 1896.

Transport Commission's Research Appointment

The British Transport Commission has appointed Mr. Charles Colin Inglis, A.M.I.E.E., to be chief research officer on its headquarters staff as from January 1, 1952. He will succeed Dr. H. E. Merritt, who is relinquishing the appointment to take up a post in private industry. At present Mr. Inglis is a deputy chief scientific officer in the Ministry of Supply. He was trained at Faraday House, London, obtaining a diploma with distinction in physics, mathematics, heat engineering and electrotechnology. After an apprenticeship with Hick Hargreaves and Co., Ltd., Mr. Inglis served with the London and South Western Railway. He was then appointed an assistant engineer in the traction department of Messrs. Merz and McLellan, with whom he remained until 1932. Mr. Inglis then became assistant engineer to the North-Eastern Electric Supply Company, but returned to Merz and McLellan in 1937 as chief engineer of the traction department. For the war period his services were utilised by the Ministry of Supply in the department of tank design and, in 1945, he was appointed to the Ministry of Supply at Chobham as superintendent of research, fighting vehicle division. Since 1948 Mr. Inglis has been deputy chief engineer in the Ministry's armament design establishment.

The British Cast Iron Research Association

The thirtieth annual report of the British Cast Iron Research Association, which was published a few days ago, covers the year ended June 30, 1951. It records that the extensions at the headquarters at Bordesley Hall, Alvechurch, which were opened last year, are now in full operation, and that the council has approved some further extensions. They include a heavy stores for pig iron, sands, refractories, and other material needed for the experimental programme, new buildings to house the chemical and sands laboratories, and a fuel and furnaces building. In the research department, the report states that good progress continued throughout the year on the study of factors influencing the fluidity of cast iron. The investigation has now been completed and a comprehensive final report is to be published shortly. Among the work initiated by the research department during the year is a long-term investigation into shrinkage and porosity defects in cast iron. As a preliminary, the investigators have spent three months visiting foundries of member-firms to obtain information on the nature of the problems and the state of knowledge on the subject. Another item of research was started during the year on the suggestion of the light castings subcommittee. An investigator has been allocated to study the factors influencing the enamelling properties of iron castings, with special emphasis on the production of castings suitable for enamelling. The investigator is making a preliminary study of these problems in the foundries of various member-firms. In a reference to the work of the Association's development department, the report says that considerable use was made of that department's staff during the year in the training of foundry personnel. An important innovation was the beginning of a series of study groups on foundry sand. The first of the courses, lasting a week, was held in April, 1951, and the response from the foundry industry was so heavy that it has been found necessary to run a one-week course every month for at least nine months to deal with the number of applicants. The total number of members of the Association on June 30, 1951, was 1239, which indicated an increase of ninety-six during the year reviewed in the report.

The Training of Operatives

During this year four specialist teams from this country have visited the U.S.A. to study problems of training for industry. These teams have been concerned, respectively, with the training of operatives, the training of supervisors, the universities and industry, and education for management. Yesterday there was published by the Anglo-American Council on Productivity the report of the first team, dealing with the training of operatives. The team, which was representative of several industries, educational institutions, trade associations and trade unions, was led by Mr. Paul G. Thomson, A.C.G.I., works director of J. Stone and Co., Ltd. Its report comments on American education, vocational guidance, recruitment and selection, apprenticeship, "in-plant" training and attitudes of management and labour to training, and sets out the conclusion that "with the exception of some aspects of apprentice training," the members of the team did not find any very revolutionary methods in the U.S.A. On the subject of apprenticeship the team considers that the first notable point about the American system is the almost complete disregard of the upper age of prospective apprentices. Men can become apprentices up to even the age of thirty-five and are not expected to begin before they are eighteen. This, the report says, gives greater flexibility and avoids the stultifying effect of the over-rigid practice in Britain, where entry into apprenticeship above the age of sixteen is unusual. The team feels strongly that the question of age limits and periods of training for apprentices should be re-examined very carefully by all industries, particularly now that compulsory national service has become a permanent feature of British life. The report also comments on the attitude of American unions towards apprentice training, saying that, in this matter, organised labour in the U.S.A. takes a much greater part than it does in the United Kingdom. The suggestion is put forward that some unions in this country might, with advantage to employer and employed, insist upon higher standards for admission to the ranks of their skilled workers.

The Modern Approach to Electrical Machine Analysis

By W. J. GIBBS, D.Sc., M.I.E.E.

No. IV—(*Continued from page 520, October 26th*)

Direct-Current Machines

THE analysis of direct-current machines is a simplification of the analysis built up in previous parts. Equations of performance can usually be derived from impedance matrices that can be written down at once. The only condition to be fulfilled is that the commutator brushes must lie in neutral positions, so that the axes of the armature currents are in line with the direct and quadrature axes of the field system.

Metadyne or Amplidyne.—Consider first a machine with one field winding and a d.c. armature winding, and sets of brushes in both axes of symmetry. The arrangement is shown diagrammatically in Fig. 5. Now, by

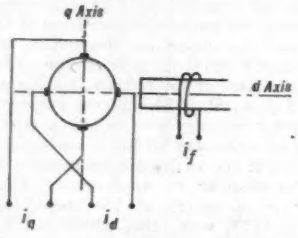


FIG. 5

following the rules formulated, the operational impedance matrix of this machine can be written at sight, thus :

	f	d	q
f	r_f+L_fp	$L_{ad}p$	
d	$L_{ad}p$	r_a+L_dp	$L_q\dot{\theta}$
q	$-L_{ad}\dot{\theta}$	$-L_d\dot{\theta}$	r_a+L_qp

....(63)

Matrix (63) is exactly the same as the impedance matrix (20) of the salient-pole synchronous machine with three windings.

Thus the only difference lies in the interpretation of the equations, because they are otherwise identical. The voltages e_d and e_q are the actual voltages applied to the armature winding, and the currents i_d and i_q are the actual currents flowing through the brushes. But in the synchronous machine the two-axis voltages and currents are fictitious, and have to be transformed after the analysis into phase quantities. Thus, the analysis of the d.c. machine is simpler in that no subsequent transformations are required.

The machine indicated by Fig. 5 is a simplified kind of metadyne or amplidyne. In the practical amplidyne there are more field windings, some of which are in series with the armature winding through the brushes. When there is an interconnection of windings like this, the analysis is better undertaken with a special technique that will be described later.

Separately Excited D.C. Machine.—Referring now to Fig. 5, suppose the commutator brushes in the direct axis are removed. The result is shown in Fig. 6, the diagram of the separately excited d.c. machine. The operational impedance matrix is obtained by simply deleting the row and column labelled *d* from the matrix (63).

In any machine where the brushes are omitted from one axis it is essential to include both direct and quadrature axes on the rotor when writing down the impedance matrix directly from the diagram. The reason for this is that the missing axis is needed to pick up the rotational voltage terms. After the matrix has been duly written out, the fact that the brushes in one axis are missing is taken care of by the deletion of the appropriate row and column. It is unnecessary to include a missing stator

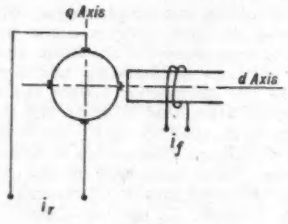


FIG. 6

axis, however, because the stator windings have no rotational voltage terms.

The operational impedance matrix for the separately excited d.c. machine is therefore

$$Z=\begin{array}{|c|c|}\hline r_f+L_fp & \\ \hline -L_{ad}\dot{\theta} & r_r+L_Rp \\ \hline \end{array} \quad ....(64)$$

and the differential equations follow from matrix multiplication with the current matrix.

The torque is clearly

$$T=-L_{ad}i_fi_r.$$

During steady state running the currents are purely direct currents, and their time derivatives are zero. Therefore p in the matrix (64) is replaced by zero and the term $-L_{ad}\dot{\theta}$ is a constant that can be denoted by k_1. Then the steady state impedance matrix becomes

$$\begin{array}{|c|c|}\hline r_f & \\ \hline k_1 & r_r \\ \hline \end{array}$$

Small Oscillations.—The machine indicated by Fig. 5 has exactly the same motional impedance matrix as the corresponding synchronous machine. The motional impedance matrix of the separately excited d.c. machine can be set down very quickly from the matrix (64). By the rules already given it is clearly

r_f+L_fp		
$-L_{ad}\dot{\theta}$	r_r+L_Rp	$-L_{ad}i_fp$
i_aL_{ad}	i_fL_{ad}	Ip^2

The currents in the matrix are direct currents. Therefore for steady state hunting p in the matrix is changed to $j\hbar$, $\dot{\theta}$ to unity, and all inductances to their corresponding reactances. The result is

r_f+jhx_f		
$-x_{ad}$	r_r+jhx_R	$-jhx_{ad}i_f$
i_rx_{ad}	i_fx_{ad}	$-Ih^2$

D.C. Series Machine.—The connections of the d.c. series machine are shown in Fig. 7. The interconnection of field and armature windings shown there can be readily taken care of when writing out the impedance matrix; but the series machine provides a suitable simple example for introducing the special technique that is desirable when the interconnections are complicated. For simplicity at this stage, assume unity ratio of turns between field and armature.

First consider the windings disconnected and independent. Then the operational impedance matrix can be written out at

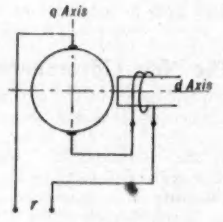


FIG. 7

once, and in this case it is the matrix (64). Denote it by the symbol Z (see equation (64).

Now, when the series connection is made, the two currents i_f and i_r become the single current i_1. Thus

$$i_f=i_1$$

and

$$i_r=i_1.$$

These two equations express the constraints on the currents set up by the series connection, the constraints reducing the number of independent currents from two to one. Set out the two equations in boxes :

$$\begin{array}{|c|}\hline i_f \\ \hline i_r \\ \hline \end{array} = \begin{array}{|c|}\hline 1 \\ \hline 1 \\ \hline \end{array} \cdot \boxed{i_1}$$

This matrix equation can be represented by

$$i=C.i' \quad . \quad . \quad . \quad . \quad . \quad (65)$$

where i is the matrix of the currents before the series connection was made, i' is the matrix of the single current after interconnection, and C is the matrix of the coefficients of i'.

The symbol C as used here is the symbol used to represent a very important class of matrices. This class includes all matrices of coefficients in the equations of constraint when interconnections are made. For that reason it is called the "connection matrix." The whole purpose of its existence and its use is to develop a routine method of making the substitutions required by the change of currents.

In the series machine the substitution by the routine method is unnecessary; the normal procedure is quite easy, and will now be used to obtain the impedance matrix of the d.c. series machine.

Expand the equations given by the matrix (64), thus :

$$e_f=(r_f+L_fp)i_f$$
$$e_r=-L_{ad}\dot{\theta}i_f+(r_r+L_Rp)i_r.$$

But after the connections are made

$$e_1=e_f+e_r$$
$$i_1=i_f=i_r.$$

Hence, by substitution,

$$e_1=[r_f+r_r+(L_f+L_R)p-L_{ad}\dot{\theta}]i_1.$$

Therefore the required impedance matrix is

$$Z'=\boxed{r_f+r_r+(L_f+L_R)p-L_{ad}\dot{\theta}} \quad ....(66)$$

Transformation of the Impedance Matrix.—Now consider the routine method of obtaining (66). The following derivation is quite general, and does not refer solely to the series machine, which is only one application of the result. The quantities used for the unconnected machine will not be primed, but the

corresponding quantities used for the connected machine will be primed, thus : Z'.

Just as

$e=Z.i$ for the unconnected machine,

$e'=Z'.i'$ . . . . . (67)

for the connected machine. To preserve the invariance of the power input or output,

$$e'.i'=e.i$$
$$=e.C.i' \text{ from equation (65).}$$

Therefore

$$e'=e.C$$
$$=C'.e \text{ by equation (53),}$$

where C' is the transpose of C.

Then since

$$e=Z.i,$$
$$e'=C'.Z.i$$
$$=C'.Z.C.i' \text{ from equation (65).}$$

Hence from equation (67)

$$Z'=C'.Z.C \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (68)$$

and this is the required relation.

Therefore in the series machine

$$Z'=\begin{bmatrix}1&1\end{bmatrix}\cdot\begin{bmatrix}r_f+L_Fp & \\ -L_{ad}\dot\theta & r_r+L_Rp\end{bmatrix}\cdot\begin{bmatrix}1\\1\end{bmatrix}$$

$$=\begin{bmatrix}1&1\end{bmatrix}\cdot\begin{bmatrix}r_f+L_Fp\\ r_r+L_Rp-L_{ad}\dot\theta\end{bmatrix}$$

$$=\boxed{r_f+r_r+(L_F+L_R)p-L_{ad}\dot\theta}$$

and this is identically the matrix (66) derived by normal methods.

The method of the connection matrix has been used for this trivial example to show quite clearly its implications. It will now be demonstrated on a more complicated machine.

The Amplidyne.—Fig. 8 shows the connections of an amplidyne with one control field winding, a series field winding in the quadrature axis connected across the quadrature axis brushes through a resistor, and a compensating winding in the direct axis connected in series with the direct axis brushes.

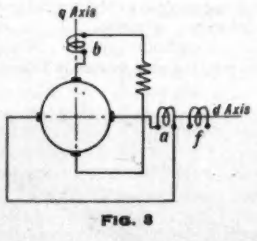


FIG. 8

The control field is labelled f. In practice there may be several control fields, but since they are independent of each other it is a simple matter to add extra rows and columns to the impedance matrix to include them. The compensating winding is labelled a and the other series winding b; the resistance r_b includes the resistance of the external resistor.

Set out the operational impedance matrix as if the winding interconnections were removed, thus :

$$Z=\begin{array}{c|ccccc} & f & a & b & d & q\\ f & r_f+L_Fp & L_{fa}p & & L_{fd}p & \\ a & L_{fa}p & r_a+L_Ap & & L_{da}p & \\ b & & & r_b+L_Bp & & L_{qb}p\\ d & L_{fd}p & L_{da}p & L_{qb}\dot\theta & r_r+L_dp & L_q\dot\theta\\ q & -L_{fd}\dot\theta & -L_{da}\dot\theta & L_{qb}p & -L_d\dot\theta & r_r+L_qp \end{array} \quad \ldots(69)$$

The equations of constraint between the currents after interconnection can then be written down, but this step is quite unnecessary, because the connection matrix can be set out at once from inspection of the connections, especially if the rows and columns are first labelled. From Fig. 8 the connection matrix is :

$$C=\begin{array}{c|ccc} & f & d & q\\ f & 1 & & \\ a & & n_a & \\ b & & & n_b\\ d & & 1 & \\ q & & & 1 \end{array}$$

where n_a and n_b are turns ratios. When windings are connected in series the turns ratio is important, and must be included in the connection matrix.

By

$$Z'=C'.Z.C,$$

$$Z'=\begin{array}{|c|c|c|}\hline r_f+L_Fp & (n_aL_{fa}+L_{fd})p & \\ \hline (n_aL_{fa}+L_{fd})p & n_a^2(r_a+L_Ap)+2n_aL_{da}p+r_r+L_dp & (n_bL_{qb}+L_q)\dot\theta\\ \hline -L_{fd}\dot\theta & -(n_aL_{da}+L_d)\dot\theta & n_b^2(r_b+L_Bp)+2n_bL_{qb}p+r_r+L_qp\\ \hline\end{array}$$

The circuit represented by the last row and column of this matrix has no voltage impressed on it. If desired, this row and column can be eliminated by the routine method. The torque can be written down from the impedance matrix. To find the motional impedance matrix, first write out the torque matrix G. Hence find $G.ip$ and $-i(G+G')$ and write out the motional impedance matrix.

The equations of small oscillations given by this matrix are :—

$$\begin{aligned}\Delta e_f&=(r_f+L_Fp)\Delta i_f+(n_aL_{fa}+L_{fd})p\Delta i_d\\ \Delta e_d&=[n_a^2(r_a+L_Ap)+2n_aL_{da}p+r_r+L_dp]\Delta i_d\\ &\quad+(n_aL_{fa}+L_{fd})p\Delta i_f+(n_bL_{qb}+L_q)\dot\theta\Delta i_q]\\ &\quad+(n_bL_{qb}+L_q)i_q\Delta\dot\theta\\ \Delta e_q&=[n_b^2(r_b+L_Bp)+2n_bL_{qb}p+r_r+L_qp]\Delta i_q\\ &\quad-(n_aL_{da}+L_d)\dot\theta\Delta i_d-L_{fd}\dot\theta\Delta i_f\\ &\quad-(L_{fd}i_f+n_aL_{da}i_d+L_di_d)\Delta\dot\theta\\ \Delta_r&=i_qL_{fd}\Delta i_f+i_q(L_d-L_q+n_aL_{da}-n_bL_{qb})\Delta i_d\\ &\quad+i_fL_{fd}\Delta i_q+i_d(L_d-L_q+n_aL_{da}-n_bL_{qb})\Delta i_q\\ &\quad+I\rho\Delta\dot\theta.\end{aligned}$$

Δe_q is zero, because the quadrature axis circuit has no voltage impressed on it. When the numerical values are inserted into these equations it is often found possible to omit certain terms as negligible. Nevertheless, the solution of the equations is very tedious unless a computing machine is available.

Consider how difficult it would be to derive these equations of small oscillations for the amplidyne by any other method. The simplicity of this modern derivation does demonstrate the power of the technique, and brings out particularly the efficacy of the connection matrix.

Induction Motors

The analysis of the induction motor is, like that of the d.c. machine, a simplification of the salient-pole machine analysis. But it is a different kind of simplification. Since both stator and rotor have regular air-gap surfaces, both members are geometrically symmetrical. Hence the axis of one phase in the stator can be selected as the direct axis.

Assuming for convenience conversion to two phases in both stator and rotor, the axis of the second phase in the stator must be the quadrature axis. For the operational impedance matrix, label the stator windings 1d and 1q and the two-axis rotor windings 2d and 2q. Then the matrix is :

$$Z=\begin{array}{c|cccc} & 1d & 1q & 2d & 2q\\ 1d & r_1+L_1p & & Mp & \\ 1q & & r_1+L_1p & & Mp\\ 2d & Mp & M\dot\theta & r_2+L_2p & L_2\dot\theta\\ 2q & -M\dot\theta & Mp & -L_2\dot\theta & r_2+L_2p \end{array} \quad \ldots(70)$$

where M is the mutual inductance between stator and rotor windings and must be the same in both axes. The resistances and total inductances must also be equal in the two axes.

Steady State Equations.—For steady state conditions the substitutions for p and $\dot\theta$ are as follows. Since the primary phase currents alternate at the supply frequency ω,

$$i_{1d}=I_m\sin(\omega t-\phi).$$

Therefore

$$\begin{aligned}pi_{1d}&=\omega I_m\cos(\omega t-\phi)\\ &=j\omega I_m\sin(\omega t-\phi)\\ &=j\omega i_{1d}.\end{aligned}$$

Similarly,

$$pi_{1q}=j\omega i_{1q}.$$

If the rotor phases are denoted by a and b, the relation between the phase currents and the quadrature axis currents is given by equations (15) thus :

$$\begin{aligned}i_{2d}&=i_a\cos\theta-i_b\sin\theta\\ i_{2q}&=i_b\cos\theta+i_a\sin\theta \quad . \quad . \quad (15)\end{aligned}$$

If the "slip" of the motor is denoted by s, the rotor speed $\dot\theta$ is $(1-s)\omega$ under steady state conditions. Therefore θ in equations (15) can be replaced by $(1-s)\omega t+\alpha$. Since the secondary phase currents i_a and i_b alternate at slip frequency,

$$\begin{aligned}i_a&=I_m\cos(s\omega t+\beta)\\ i_b&=I_m\sin(s\omega t+\beta).\end{aligned}$$

Substituting these values into equations (15) gives

$$i_{2d}=I_m\cos(\omega t+\alpha+\beta)$$

and hence

$$pi_{2d}=j\omega i_{2d}.$$

Similarly,

$$pi_{2q}=j\omega i_{2q}.$$

Therefore, for steady state running, replace p throughout the impedance matrix (70) by $j\omega$ and $\dot\theta$ by $(1-s)\omega$. The result is the matrix

$$Z=\begin{array}{c|cccc} & 1d & 1q & 2d & 2q\\ 1d & r_1+jx_1 & & jx_m & \\ 1q & & r_1+jx_1 & & jx_m\\ 2d & jx_m & (1-s)x_m & r_2+jx_2 & (1-s)x_2\\ 2q & -(1-s)x_m & jx_m & -(1-s)x_2 & r_2+jx_2 \end{array} \quad \ldots(71)$$

Owing to the fact that there are no salient poles in this machine, the impedance matrix (71) can be simplified, and the nature of the simplification depends on whether the applied voltages are balanced or not. Each condition will now be considered in turn.

Balanced Supply Voltages.—When the supply voltages are balanced the only difference between the conditions in phase d and those in phase q is one of time. The per unit current in both phases is the same and can be denoted I_1 for the stator and I_2 for the rotor. Since phase q is 90 deg. out of time phase with phase d, j can be used as a time operator giving the relations

$$i_{1d}=I_1 \qquad i_{1q}=-jI_1$$

and

$$i_{2d}=I_2 \qquad i_{2q}=-jI_2.$$

These equations are equations of con-

straint between the currents, and when they are set out in boxes they form the matrix equation :

$$\begin{bmatrix} i_{1d} \\ i_{1q} \\ i_{2d} \\ i_{2q} \end{bmatrix} = \begin{bmatrix} 1 & \\ -j & \\ & 1 \\ & -j \end{bmatrix} \cdot \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \quad \text{....(72)}$$

or

$$i = C.i'$$

where C can be treated as a connection matrix.

However, there are two points to be noted about this connection matrix. The first is that, in order to preserve the invariance of power the matrix must be multiplied by $1/\sqrt{2}$. The second is that the elements of the matrix are not all real, and therefore the elements in the final impedance matrix must be complex. Now, when complex quantities are used in electrical circuits the power is given by e^*i, where e^* is the complex conjugate of e. The transformation from Z to Z' differs from that given in equation (68). The rule of transformation when C is complex will now be derived.

Since the power is invariant,

$$e^{*\prime}.i' = e^*.i$$
$$= e^*.C.i'.$$

Therefore

$$e^{*\prime} = e^*.C$$

and hence

$$e' = C^{*\prime}.e,$$

where $C^{*\prime}$ is the transpose of the conjugate of C.

Then

$$e' = C^{*\prime}.Z.i$$
$$= C^{*\prime}.Z.C.i'$$
$$= Z'.i',$$

and therefore

$$Z' = C^{*\prime}.Z.C \quad . \quad (73)$$

Thus when the connection matrix is complex the transpose of the conjugate must be used in the transformation of Z instead of the plain transpose.

From C in equation (72) using the factor $1/\sqrt{2}$,

$$C^{*\prime} = \begin{bmatrix} 1 & j & & \\ & & 1 & j \end{bmatrix} \times 1/\sqrt{2} \quad \text{....(74)}$$

Z is given in equation (71)). Therefore

$$C^{*\prime}.Z.C = Z' = \begin{bmatrix} r_1 + jx_1 & jx_m \\ jx_m & r_2 + jsx_2 \end{bmatrix} \quad \text{....(75)}$$

The impedance matrix (75) gives the voltage equations under steady state conditions of the balanced polyphase induction motor.

(To be continued)

A Twenty-Cubic-Yard Walking Dragline

No. I

A PARTICULAR problem in opencast ironstone working in this country is the removal and disposal of the overburden. Some years ago, when it became evident at the Corby workings of Stewarts and Lloyds, Ltd., that an overburden some 100ft deep would be encountered, it was decided to install a walking dragline of a size and capacity well beyond that of any similar machine hitherto constructed. The design and construction of such a machine had long been studied by Ransomes and Rapier, Ltd., Waterside Works, Ipswich, and in November, 1947, an order was placed with this firm for a walking dragline with a capacity reach of 20 cubic yards at 260ft radius. The placing of the order for such an outstanding machine with this firm was a natural outcome of the close liaison which had existed for some twenty years between the two companies, based upon the fact that at seven of the major mines serving Corby, 9-cubic-yard Rapier shovels are used for stripping the overburden.

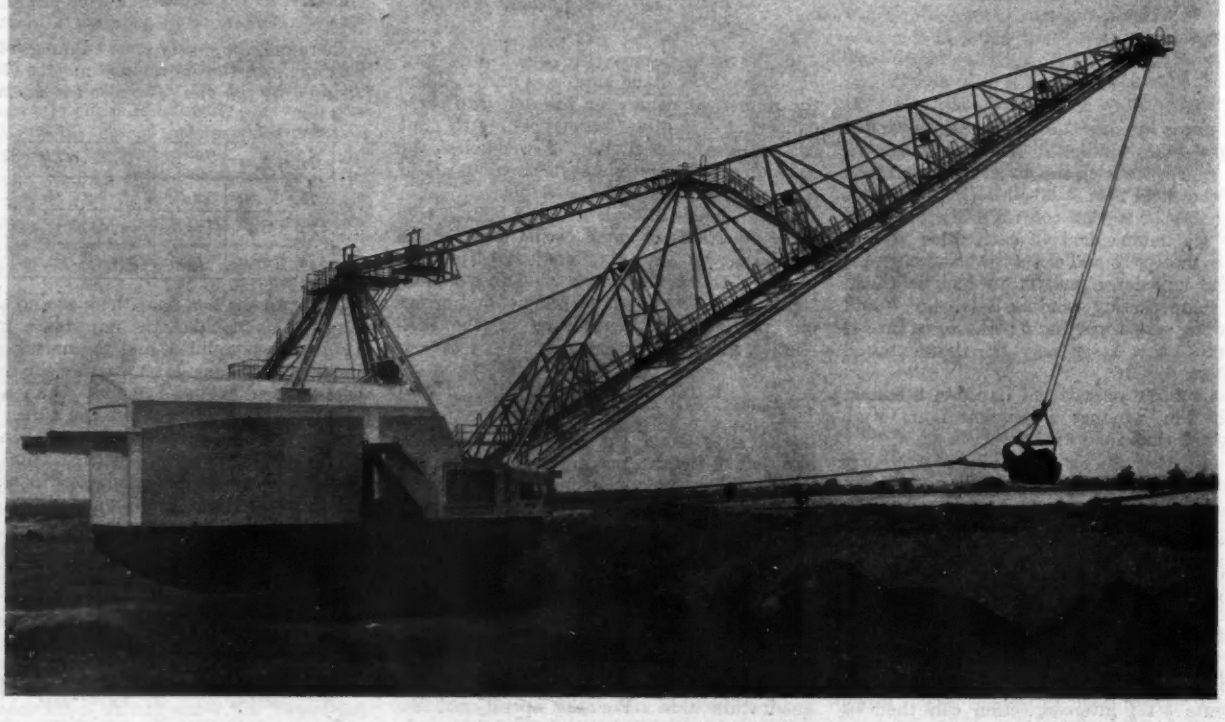
The walking dragline itself was built at Waterside Works and erected on site by Stewarts and Lloyds' engineering staff at Corby. The tubular, all-welded, 282ft long boom was designed in conjunction with the staff of Tubewrights, Ltd. and that company was also responsible for its construction. The main electrical equipment of the machine and its control gear was made and supplied by the British Thomson-Houston Company, Ltd., of Rugby.

On Wednesday last, at the invitation of Stewarts and Lloyds, Ltd., we had an opportunity to see this new dragline in operation at Corby.

The general design and construction of the dragline can be seen in the photographs reproduced herewith and the drawings in the Supplement. The main particulars of the machine are as follows :—

Length of jib, centre of pulley pin to centre of foot pin	282ft
Capacity of bucket	20 cubic yards
Angle of jib to horizontal, approx.	30 deg. to 35 deg.
Radius of discharge—vertical ...	260ft to 247ft
Maximum allowable working load at maximum radius	52 tons
Dump height at maximum radius, approx.	120ft to 140ft
Clearance radius of cab	68ft 6in
Centres of shoes	63ft
Width of house	49ft
Diameter of roller circle	47ft
Diameter of base structure ...	48ft
Area of base	1,809 square feet
Two shoes, each	48ft by 9ft 6in
Bearing area of shoes, each	445 square feet
D.C. drag motors, 4 off continuously rated blown, each	225 h.p.
D.C. hoist motors, 4 off, continuously rated, blown, each ...	225 h.p.
D.C. rotate motors, 2 off continuously rated, blown, each	225 h.p.
D.C. walking motors, 4 off continuously rated, blown, each ...	225 h.p.
Motor generator sets, 2 off, driving motors, each	1,500 h.p.
Drag rope, twin, each	7in circ.
Hoist rope, twin, each	6½in circ.
Jib hoist rope, ten parts	6in circ.
Working weight	1,650 tons
Ballast	Nil

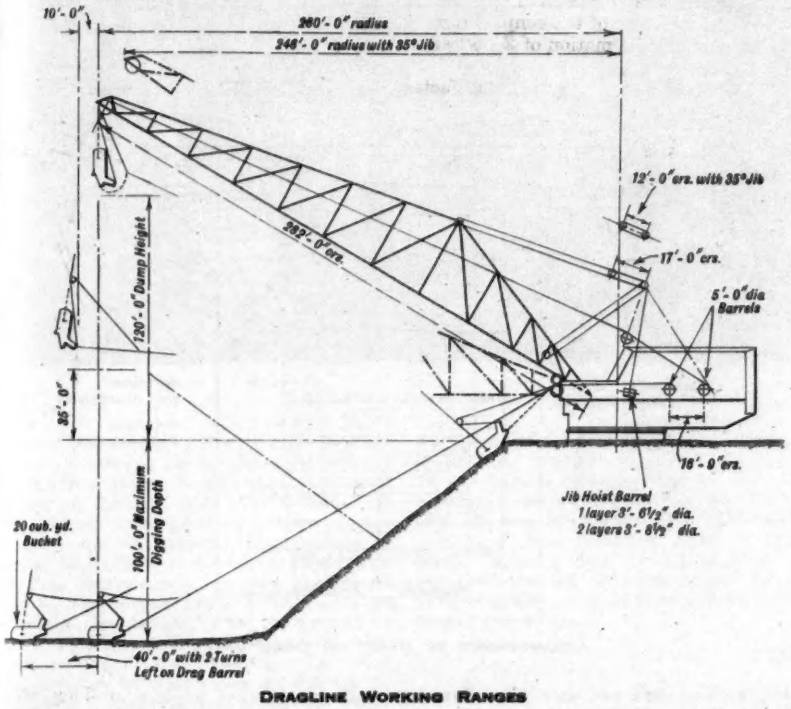
The working ranges of the machine are shown in the drawing opposite. It is electrically operated throughout with Ward-Leonard amplidyne control and power is taken at 6600V



TWENTY-CUBIC-YARD WALKING DRAGLINE

through two trailing cables. One man operates the machine from either of two control cabins provided on each side of the main structure, and arranged to give a clear unobstructed view of the boom and bucket.

When working on well-blasted material which gives straightforward filling of the bucket, the machine is designed to complete the following working cycle in sixty-one seconds:—Dig material and fill the bucket as near the maximum radius as practicable at the foot of a cut 50ft below its level, hoist the load and rotate through 90 deg. to a dumping position 104ft above the machine level, dump the load, rotate back to the digging position and lower the shovel to the filling point. Alternatively, in eighty-one seconds, when digging material 50ft above the machine level, the bucket can be filled near maximum radius, hoisted 104ft, rotated through 180 deg. to the dumping position, and after dumping rotated back in the reverse direction to the digging position. When walking, the machine is designed to traverse any reasonably flat ground on the level, or, in either direction, on a gradient of not more than 1 in 12.



DRAGLINE WORKING RANGES

The base structure of the machine is 48ft diameter and, complete with the rotating rack, roller path and live ring of rollers, weighs some 227 tons. It is a riveted, welded and bolted assembly of rolled steel plates and sections well braced to support the main roller path and rack, and give the necessary strength and rigidity for digging and walking. This structure can be seen in process of assembly, and when completed at the maker's works in the photographs on this page. It is 4ft deep between the top and bottom plates and is built up on sixteen full-depth radial girders with full-depth circular girders under the rack and roller path.

The centre post of the base structure is a mild steel forging 6ft 2¾in high, welded into a structural frame; this assembly in turn forms an integral part of the main structure and on to it butt all of the machined web ends of the radial girders. The flanges of these beams were formed with spear ends to cover the top and bottom circular plates of the centre post unit to obtain continuity of flange strength. In order to ensure the maximum strength and that the beams would register accurately on assembly, all of the mating faces on the centre post and the beams were machined to close limits during manufacture. The centre post head, about which the superstructure rotates, is 2ft 4in diameter and stands 2ft 3in above the top of the base surface.

The roller path has a mean diameter of 47ft with a 7½in wide face, and is built up of thirty-two nickel-chrome-molybdenum cast steel segments of bridge type rail section machined both top and bottom. It carries the 120 alloy steel tapered rollers of 10in mean diameter which form the live ring. These rollers are mounted on a frame, consisting of an inner and an outer heavy channel member, and are grouped into small cage units of four rollers to facilitate withdrawal and replacement.

A heavy hook rail, consisting of a solid mild steel bar bent to shape after machining, which is bolted under the top projecting flange of the main circumferential beam of the base, is designed to distribute the lifting hook loads over the structure. The rack for the rotate gear is built up of sixteen cast steel segments securely fixed to the main base frame by 196 bolts, 2in diameter. This rack has 208 teeth, 6in circular pitch, 1ft 7in deep, on a pitch circle diameter of 33ft 1·2in.

In the web of the circumferential girder two oval openings are provided for the entry of the trailing high-tension cables used to connect the machine to the main power supply. These openings are stiffened by cast steel fairings. Within the structure the fairings are fitted with hinged and split bell mouths, which, in addition to extending the fairings so that cables can enter without reducing the bend radii beyond safe limits, can be swung open to give free entrance for the half junction boxes when changing cables. Cable-end couplings for 300A, 6600V, are fitted.

The revolving superstructure has been designed as a cantilever unit supported at one end on the live ring of rollers. It is built up on a frame of rolled steel plates and sections, consisting of four main 75ft 9in long longitudinal girders, each 14ft deep, spaced at approximately equal distances transversely and connected at the forward end to a circular girder of equal depth. The rear third of the circular girder is reduced to half depth and has intermediate full depth girders; a rear external transverse girder 17ft deep, is provided and the whole unit is carried on the live ring of rollers under the circular girder. As this main rotating frame unit is plated over top and bottom, a structure has been obtained sufficiently stiff to distribute effectively the heavy external and the local machinery loads with negligible deflections. It should be noted here that the main girders were constructed at the works of the Cleveland Bridge Company, Ltd., with a depth equal to half their finished depth, to facilitate manufacture and transport, and they were assembled on site by riveting.

The main boom feet and front A-frame legs are supported through pins on fabricated bracket assemblies located and bolted over the point where the main outer girders and the front tranverse girders of the superstructure base join the circular girder. In order to ensure a wide distribution of these two localised loads on the machine, over as many rollers as

BASE STRUCTURE DURING ASSEMBLY

BASE STRUCTURE ASSEMBLED

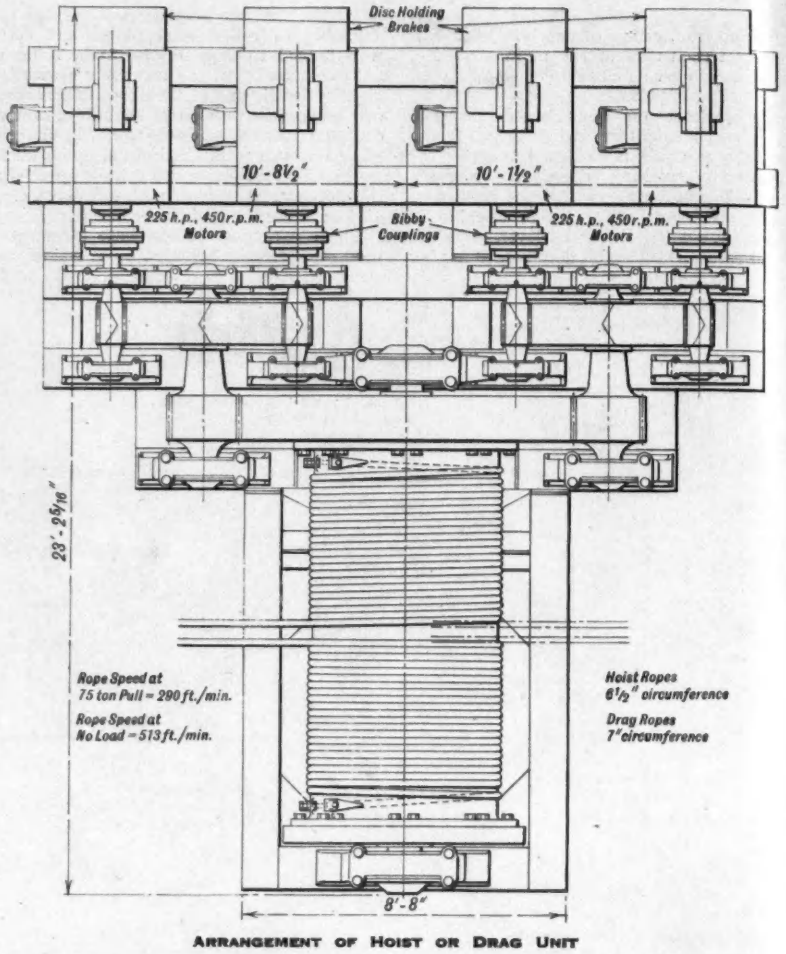
possible, the areas where they are connected to the frame are well reinforced and doubling plates are added to the webs of the circular girder. To provide for the effective distribution of the walking, dragging and rotating loads through to their reactions at the centre-post, heavy welded reinforcing units are fabricated into the structure.

Provision has been made effectively to distribute the superstructure loads through the longitudinal girders to the walking axles by introducing a deep transverse bridge girder,

WALKING ECCENTRIC

which forms an integral part of the superstructure. When the machine is walking, two-thirds of the weight of the base is carried by a hook system connected to the underside of this transverse girder.

The walking gear has been designed on the Cameron and Heath method of propulsion, used exclusively in all Rapier walking draglines, in which the main walking shafts are relieved of all bending moments. In this machine two hollow steel forgings, each 2ft 11in on the maximum diameter, 13ft 11in long and weighing nearly 8 tons, are welded into the outer ends of the bridge girder to form the axles for the walking eccentrics. These eccentrics, one of which can be seen in the illustration above, are bronze-bushed to rotate on the outer diameter of the axles. The forged steel, 32ft long, transmission shafts



ARRANGEMENT OF HOIST OR DRAG UNIT

of the walking unit are each 20in diameter and weigh 16½ tons. They have squared ends, which are keyed in recesses machined in the eccentric bosses.

Each eccentric is a welded assembly, built up on a heavy cast steel boss, and its outer surface forms the inner race of a large roller bearing, having fifty-two carbon steel rollers, each of which is 6in diameter and has an effective length of 1ft 10in. A machined path, 9ft 9½in diameter, in the centre of the walking leg (illustrated below), provides a seat for the roller bearing of the eccentric. The throw of the eccentric is 2ft 2in and its rotation gives a walking stride of 6ft 10½in.

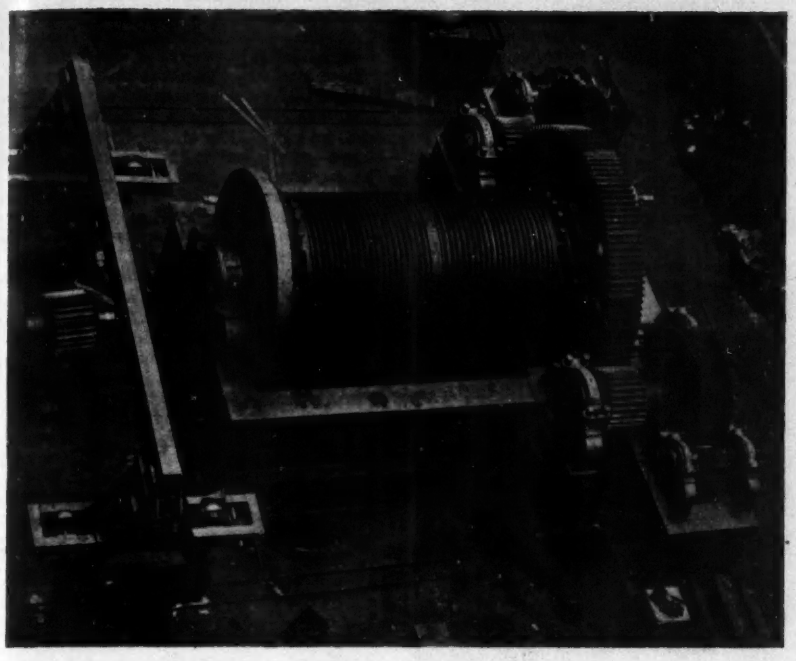
In each of the fabricated walking legs steel castings are used in the formation of the lower end, which has a split bronze spherical bearing for a universal ball connection, forged on the walking shoe axle. The connection of the walking leg to the shoe through this universal type of bearing gives the shoes a degree of movement in all planes and so permits them to bear evenly when the machine is travelling on irregular ground.

The upper ends of the legs are connected through links to stub axles formed by projections of the upper member of the walking bridge girder. These links serve to constrain the upper end pin to move in an arc during a revolution of the walking eccentric so that the lower end of the leg—that is, at the shoe-axle centre—describes an elliptical path, the major axis of which is approximately horizontal. The length of this major axis represents the length of each step and the height of the minor axis represents the lift of the shoe plus the lift of the walking shaft above the ground.

The two walking shoes, each 48ft long and 9ft 6in wide, are built up of mild steel plates and specially shaped fabricated broad flange beams. At each end, on its underside, a shoe has attached a heavy angle section, which is designed to increase its grip on the surface of the ground when walking. Each shoe weighs 56 tons.

On any walking machine of this kind it is possible during movement for one shoe to slip a greater distance in relation to the other shoe and in so doing force the two shoes out of parallel with the machine axis. To prevent this occuring there is fitted a special shoe return mechanism, invented by Cameron and Balicki, and provisionally patented by Ransomes and Rapier, Ltd. This device consists of a long, preloaded, tubular torque member, having inner and outer tubes and mounted on

WALKING LEG



HOIST OR DRAG UNIT

the side of the machine. Heavy levers depending from a bracket in the middle of each torque member are connected through rods to universal couplings at the rear ends of the shoes. If during the walking operation a shoe rotates about its axis, an angular displacement is imparted to its lever through the connecting-rod. This displacement increases the stored energy in the torque tube, which reacts as soon as the shoe is lifted from the ground to return it to its normal position parallel with the centre line of the structure. The shoe return gear can be clearly seen on the side of the machine in the isometric projection reproduced in our Supplement.

The inner ends of the driving shafts for the walking gear are cantilevered through journal bearings mounted on facing plates carried on the inner longitudinal girders of the superstructure. The ends of the shafts are squared and on to them are keyed the main driving wheels. The walking drive consists of two separate motor-driven units, one for each shaft. In each of these units two 225 h.p., 450 r.p.m., 230V continuously rated motors drive a double helical gear through pinions arranged at each side to form a balanced drive. From this helical gear drive is taken through straight spur gear reductions to the walking shafts. These two pinions driving the walking shafts engage the main wheel at diametrically opposite points to form a balanced load and ensure that no bending from tooth loading is taken by the shaft.

The hoist and the drag units, one of which can be seen in the illustration above and the drawing on page 550, are each of identical design except for the drum grooving. They are self-contained units mounted on the top deck of the revolving superstructure, and, as in the case of the walking unit, a balanced drive is provided on each unit from four motors. No operating brakes or clutches are incorporated in the design, but a disc-holding brake is provided on each motor. The units have similar motors to those used in the walking drive, and on them the total gear ratio is 29·2 : 1. They have machine-cut double-helical first reductions in which the pinions are driven through flexible couplings and arranged diametrically opposite on the gear wheels. In the second reduction—where machine-cut straight gears are used—the pinions are cut from the solid shaft and again arranged diametrically opposite to gear with the main drum wheel. The 5ft diameter drum is arranged for two ropes winding two, the fixing being at each end of the drum with right and left-hand grooving to the centre. For both hoist and drag the maximum pull is 100 tons (stalled) and the rope speed, at 75 tons pull, is 290ft per minute. At no load the rope speed is 513ft per minute. Twin 6¼in circumference hoist ropes, each 685ft long, are used, and these ropes are designed with an actual breaking load of 151·4 tons. The 7in circumference twin-drag ropes are each 347ft long, and are built for an actual breaking load of 182·4 tons.

The superstructure is rotated by two units housed on the right and left-hand sides of the machine between the decks and forward of the centre of rotation. Each of these units is driven through a gear type coupling by a vertical 25 h.p., 450 r.p.m., 230V continuously rated motor, and is completely self-contained with the gears mounted in oiltight fabricated steel boxes. The total gear ratio is 775 to 1 and the main rotating pinion, which is forged integral with the final shaft, has machine-cut teeth of 6in circular pitch. With this rotating gear the no-load revolutions of the superstructure are 1·225 per minute, which is equivalent to 2000ft per minute at the jib head.

In all of the motors used on the walk, hoist, drag and rotate units, the shaft assemblies, comprising the shaft armature, commutator and bearings, are interchangeable with one another, both electrically and mechanically. In the hoist, drag and walk motions, the operating coils of the brakes are arranged to operate in groups of four in series on 125V d.c., and those of the swing motion in groups of two in series on a similar voltage. With these arrangements there is a high degree of interchangeability, and maintenance is simplified and it will only be necessary to maintain a minimum stock of service replacements for the machine in the field.

For jib hoisting purposes a self-contained winch unit is mounted on the main deck at the forward end of the house. This unit is driven by a 440V, 965 r.p.m., three-phase, slip-ring, induction motor. with a 16in diameter brake fitted on a shaft extension at the slip-ring end. Drive to the winch is taken through worm and spur gearing, and the Thrustor-operated brake gear is employed to obtain slow-speed control. It has a 4ft 6in diameter drum and ten parts of a 6in circumference rope 760ft long are used. When the jib has been positioned through this hoisting gear, safety links are fitted between the main suspension member, and the A frame, to release the tension from the jib hoist unit and from the rope.

(To be continued)

1700kV Impulse Generator

LAST week we visited the Charlton works of Johnson and Phillips, Ltd., to see the 1700kV, 30 kilowatt-second impulse generator which the company has designed, manufactured and installed as part of its high-voltage test plant. It is being used for investigation of surge voltage characteristics and for the routine impulse testing of transformers, cables, switchgear, sealing ends and bushings.

The installation consists of a 200kV direct-current charging unit, comprising a transformer feeding a half-wave rectifier; a twelve-stage, two-column impulse generator (Fig. 1); a capacitor-screened resistance potential divider; a high-speed sealed glass tube, double beam, cathode ray oscillograph with recording camera; and a control desk. For uniformity of appearance the transformer, the rectifier and the generator capacitors are housed in 23in diameter black bakelised paper tanks, fitted with cast aluminium end rings and corona shields. The overall height of the generator is 18ft. which corresponds to a figure of 10·6ft per megavolt.

The d.c. charging unit consists of a 200kV, 6·6kVA transformer, a 250kV peak half-wave rectifier and a limiting resistor. A view of the transformer ready for tanking appears in Fig. 2, and the complete unit can be seen on the extreme left of Fig. 1.

A 230V supply is fed through a 0–250V "Variac" regulator to the primary of the 200kV transformer. This transformer, designed and manufactured by the company's transformer department, has a tertiary winding for cascade operation and the core is at 100kV. It is housed in a black bakelised paper oiltight tank and the output terminal is the top corona shield which is connected directly to the rectifier.

The half-wave copper oxide rectifier is mounted on an insulated base so that positive or negative d.c. may be obtained by connecting the transformer output to the bottom or top of the rectifier unit, the opposite end of which is connected via an oil-filled limiting resistor to

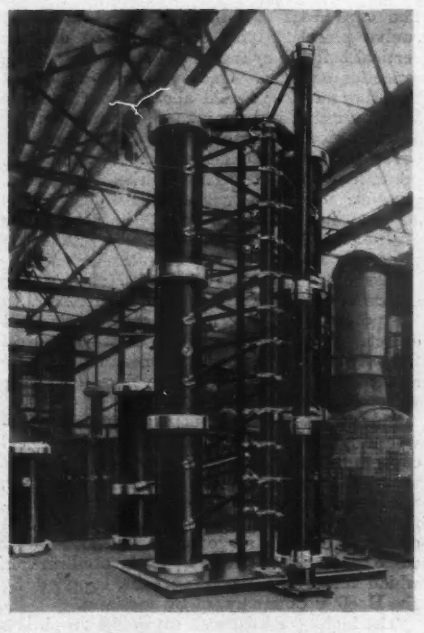


FIG. 1—1700kV IMPULSE GENERATOR

the first capacitor of the generator. The limiting resistor passes a maximum current of 30mA at full voltage.

At the output end of the limiting resistor is a solenoid-operated earthing switch, which automatically earths the generator when the transformer is de-energised, either from the control desk or by the opening of any of the interlocked gates of the test area. There is a short time lag in the earthing operation, which is just sufficient to ensure that the main contactor on the input side of the transformer opens before the generator is earthed and thereby avoids short circuiting the equipment.

The Impulse Generator

The generator uses a conventional Marx circuit and consists of twelve stages, one capacitor per stage, arranged in two columns of three tanks, each tank containing two capacitors. Each of these high-voltage capacitors (Fig. 3), which were designed and manufactured by the company's capacitor department, consists of 198 flat elements, has a total capacitance of 0·255 microfarads, and may be charged to a maximum voltage of 142kV.

With the twelve stages in series the maximum output voltage of the generator is 1·7MV and the total energy output is 30 kilowatt-seconds.

FIG. 2—6·6kVA WOUND TRANSFORMER CORE AND TANK

The capacitors are discharged by means of twelve pairs of 10cm spheres fitted on two vertical bakelite cylinders situated between the capacitor columns. One cylinder is fixed and the other may be rotated about its vertical axis by a lever arm and screw mechanism driven by a small electric motor fitted under the base cover plates of the generator. A slide wire potentiometer, operated by the lever arm, gives an indication on the control desk of the gap setting. Adjustment of the gap is by push-button "start" and "stop" switches on the control desk.

The output from the final stage of the generator is taken, via a damping resistor, to the potential divider and thence to the test object. Sets of resistors in each stage control the output waveform and the resistors may be replaced by others of different values to suit the various load conditions.

The potential divider is a simple resistance-wound unit surrounded by a tube of cylindrical capacitors which screen the resistors and, at the same time, put a small load on the generator, thus reducing the effect on the output waveform of variations in test load. From the foot of the divider the surge is fed through a delay cable to the deflection plates of the oscillograph, which forms the recording unit, supplied by the Haefely Company, of Switzerland.

The high-speed cathode ray oscillograph is a sealed glass tube working at 20kV accelerating voltage and incorporating two beams for simultaneous recording of voltage and current surges. Sweep speeds from 0·3 microsecond to 1000 microseconds are available, together with timing "pips" covering a range of time intervals from 0·1 microsecond to 100 microseconds. For voltage measurement fixed calibrating voltages are provided. Initiation of sweeps and brightening pulses is effected by a valve relay operated at the instant of firing of the first-stage gap. A 35mm recording camera is used in conjunction with the oscillograph

FIG. 3—HIGH VOLTAGE CAPACITOR ASSEMBLY

for obtaining permanent oscillographic records of all tests.

To enable the operator or customers' representative to monitor tests which are being photographically recorded, a single-beam, 10kV, high-speed oscillograph is being provided by the company's instrument department, which has already manufactured a recurrent surge oscillograph for surge investigations on transformer windings.

The generator is operated from a control desk outside the test area. This control desk (Fig. 4), designed and manufactured by the

FIG. 4—CONTROL DESK

company's switchgear department, houses the voltage regulator (under the control of the handle on the right-hand side of the desk), the push-button switches and associated contactors for energising the 200kV charging transformer, and the push-button switches for adjustment of the generator sphere gaps. Indication is given, by meters on the control desk, of the voltage and current input to the charging transformer, the gap setting and the mean stage voltage. The mean stage voltage is indicated on a microammeter connected through a 3000megohm resistor to the high-voltage side of the first-stage capacitor, the microammeter being scaled in kilovolts.

In operating the generator the three-electrode method of controlling generator tripping is not used, although provision has been made for its addition at a later date. For single surges the stages are charged to the required voltage and the gaps are then closed until discharge occurs. For repetition shots at a constant voltage the generator is allowed to charge continuously with the gaps set for flashover at the required discharge voltage. For chopped waves, as required in transformer tests, a standard rod gap for voltages up to 750kV is connected in parallel with the generator.

At present, owing to building restrictions, the impulse generator is installed in a screened-off portion of the high-voltage test area in the transformer department. There, however, the clearances to the building structure restrict the operating range of the generator to something of the order of 900kV. Subject to the grant of the necessary building permits, it is intended eventually to house the equipment in a separate building, where it will be possible to make full use of the voltage and capacity of the impulse generator.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

STEAM TURBINES

No. 132 : 1951. This is a revision of B.S. 132, "Steam Turbines," which was originally issued in 1930, and it includes a number of improvements as compared with the original edition. Although intended mainly for steam turbines for use in electric power stations, many of its provisions apply to steam turbines for other service. The progress made during the last twenty years is reflected in this standard by new features. These refer chiefly to supervisory instruments, turning gear, precautions to be taken with larger turbines in respect of falling vacuum and operation of condensing turbines under non-condensing condition. Of special interest are the recommended limits of variation in steam pressure and temperature from the rated values in actual operation of plants with modern advanced steam conditions; while these limits are at present to be regarded as tentative only, more definite guidance will be provided as soon as growing experience with advanced steam conditions will permit. A table of recommended standard ratings with their particular operating conditions is also included; this table covers the range of 10,000kW to 100,000kW range. Price 2s., post free.

CARBON STEEL CASTINGS FOR SURFACE HARDENING

No. 1760 : 1951. This is one of a series of standards being prepared for steel castings for general engineering purposes. It covers the requirements for carbon steel castings for surface hardening by a local heating and quenching process. Two grades are specified: Grade A is required to show a tensile strength of 40 tons per square inch and a surface hardness after hardening of 550 D.P.N., and Grade B is required to show a tensile strength of 45 tons per square inch and a surface hardness after hardening of 600 D.P.N. The full chemical composition is specified for both grades. Inspection and testing are covered in detail and an appendix gives recommendations on the repair of castings by metal-arc welding. Price 2s. post free.

KNURLING WHEELS

No. 1759 : 1951. This relates to knurling wheels having straight and spiral teeth, which can be arranged to produce any normal knurling, including the diamond form. Details of four grades are given; they are differentiated by the number of teeth per inch, while a fifth grade suitable for use in hand knurling tools is also included.

The specification gives details of the main dimensions and tolerances, and specifies certain manufacturing and material requirements. It also gives instructions regarding the markings on the wheels. The appendices include notes on knurling operations and give illustrations of some of the popular designs of complete knurling tools used on capstan and automatic lathes. Price 3s. post free.

Recording Voltage Transients During Fuse Operation

By E. B. CARNE, B.Sc.(Eng.)*

THE process of current rupture by means of fuses generally produces a voltage surge, which is initiated at the instant of break up of the fusible element. It is desirable to have an accurate record of the shape and magnitude of the surge, since it provides important information for the fuse designer and also for the user of any particular kind of fuse. The duration of the surge voltage is usually of the order of 200 to 300 microseconds. A Duddell oscillograph can be used to give much useful information of phenomena accompanying fuse operation, but the only instrument capable of producing an accurate record of the voltage surge is the cathode-ray oscillograph. The use of a cathode-ray oscillograph is complicated by the fact that, even under controlled short-circuit conditions, it is impossible to predict within a few microseconds the instant at which the fusible elements will disintegrate, and, in such tests, the customary method of recording the voltage surges has been by using a cathode-ray oscillograph incorporating a rotating drum camera. This method involves the use of long lengths of film or paper for each test while the actual length of the desired record is only a few centimetres. The speed of rotation of the drum must be high to secure a record having sufficient detail and is limited to about 167ft per second, which is the maximum peripheral speed obtainable with such apparatus. At Queen Mary College records of the surge voltages or transients occurring during fuse operation have been obtained without using a rotating drum. The method utilises a "transient recorder," which comprises a cathode-ray oscillograph with a single-stroke time-base and means for "tripping" the time-sweep at the correct instant of fuse operation. A three-phase transient recorder was employed and one phase of this instrument is described below. The other two phases are similar.

Three-Phase Transient Recorder

The equipment used incorporates three sealed-off, glass, cathode-ray tubes, operating at a maximum anode voltage of 5kV. A single-stroke time-base, tripping circuit and calibrating oscillator are common to all three tubes but the signal channels are separate and can be operated independently of each other. The signal channel comprises a probe unit and an amplifier. An outline diagram of the signal channel is given in Fig. 1.

The signal voltage, which may be as high as 10kV, is applied to a resistance-capacitance, frequency-compensated, voltage dividing chain and a cathode follower. These components form the separate "probe" unit shown in Fig. 1, which may be placed close to the main circuit, in which the fuse is situated, while the remainder of the equipment can be some distance away. The voltage appearing across the cathode load of the cathode follower is fed to an amplifier through a matched two-microsecond delay cable. Wide-band amplification is achieved by two pentode valves working as a long-tailed pair, which produce a symmetrical deflection voltage on the Y-plates of the cathode-ray tube. The anode loads of the two valves are frequency compensated to give a level response up to a frequency of about five megacycles per second. Their power supplies, in common with the supplies for the other circuits, are stabilised against input voltage and load current variations.

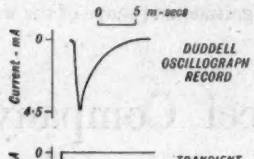


FIG. 2—RECORDS OF CONDENSER DISCHARGE CURRENT

The single-stroke time-base is controlled by a thyratron trigger circuit, which is fired by a tripping voltage received from the probe unit through a cable having a delay of one microsecond. Simultaneously with the initiation of the time sweep a beam brightening pulse is applied to the grid of the cathode-ray tube. Time-sweeps ranging from 250 milliseconds to 10 microseconds can be obtained by variation of the sweep condensers.

Three optical systems allow the traces on the three tubes to be photographed side by side on the same film or recording paper.

Test Results

(*a*) *Comparison with Duddell Oscillograph.*—It is of interest to compare the accuracy of records obtained from the equipment described with that obtained from a Duddell oscillograph. Fig. 2 shows records of a condenser discharge current taken simultaneously by a Duddell oscillograph and the equipment described above. The waveform is, of course, exponential and calculations give a maximum current peak of 4·8mA, a time of rise to maximum current of about 40 microseconds and a time constant of 2·4 milliseconds. There is an uncertainty with regard to the time of rise to a maximum since this depends on the stray inductance of the leads and the proper closing of the switch initiating the discharge. The records, when analysed, yield the following results:—

Comparison Between Duddell Oscillograph and Transient Recorder

	Time of rise to maximum	Maximum current	Time to fall to $\frac{4\cdot8}{\varepsilon}$ mA
Duddell oscillograph	600μ sec (error = 1400 per cent	4·5mA (error = 6 per cent)	3·3m sec (error = 36 per cent)
Transient Recorder	50μ sec (error = 25 per cent)	4·8mA	2·5m sec (error = 4 per cent)

As can be seen from these figures, the Duddell oscillograph record shows quite large percentage errors when compared with the theoretical values. As the transient disturbance becomes more rapid these errors grow, due to the inability of the mechanical system to follow frequencies above a few kilocycles per second. The transient recorder, on the other hand, shows figures well in agreement with the calculated values: indeed, the discrepancies can quite easily be accounted for by errors in the measurement of the trace. This result is not surprising with the great increase in frequency response and the small inertia of the electron beam as it sweeps out the trace on the face of the cathode-ray tube.

(*b*) *Application to the Recording of Voltage Surges on Fuse Operation.*—The voltage appearing across the fuse as the current is ruptured is attenuated in the probe unit and appears as a signal of some 8V or 10V across the load of the cathode follower. This signal is applied to the input of the

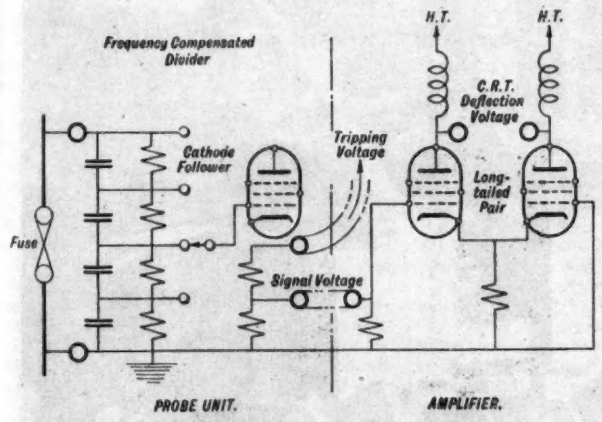


FIG. 1—SIGNAL CHANNEL

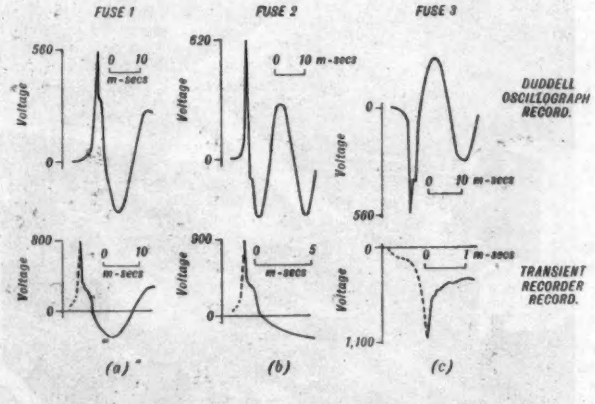


FIG. 3—COMPARISON OF FUSE OPERATION RECORDS

*Research Student, Electrical Engineering Department, Queen Mary College (University of London).

signal amplifiers and also, by way of the tripping voltage terminal (see Fig. 1) to the time base circuits in such a way that the initial rise of voltage produces a voltage pulse sufficient to trigger the time base. Only a very small disturbance is required to initiate the time-sweep so that little of the fuse transient is lost. Fig. 3 shows examples of records of the voltage rise across a fuse taken on different occasions on one of the three cathode-ray tubes comprising the equipment. For the purpose of comparison, records obtained simultaneously on a Duddell oscillograph are also shown.

The sweep speed of the transient recorder has been successively increased from 25 milliseconds in Fig. 3 (*a*) to 8 milliseconds in (*b*) and to 2 milliseconds in (*c*), in order to give some idea of the detail obtainable with the instrument. It will be seen that the initial voltage rise is not the smooth curve shown by the Duddell, rather is it a series of serrations. Also there are considerable discrepancies between the peak voltages recorded by the two instruments, the final peak of the wave being so sharp that it lies above the Duddell cut-off frequency. Finally, the Duddell oscillograph seems to give serious distortion of the main features of the transient. An obvious example is seen in Fig. 3 (*b*), where the voltage falling from its peak value, forms a hump before falling to zero and taking up the normal recovery voltage of the system. No such point appears above the zero line on the Duddell record, though there is a disturbance below the line where the voltage seems to take on the normal system voltage.

Conclusion

The transient recorder described above is capable of recording the rapid voltage transients accompanying fuse operation without the use of a rotating camera and long lengths of film. The writing speeds obtainable are much greater than the maximum that can be achieved with mechanical devices. The frequency response of the transient recorder is far superior to the Duddell oscillograph, which can only be relied upon to follow comparatively slow-speed phenomena without serious distortion of the magnitude and shape of the wave.

The Works of the Steel Company of Wales

No. I

THE major item in the reconstruction scheme for the steel industry, which was put forward by the British Iron and Steel Federation at the end of the war, was the £60 million project for the South Wales sheet steel and tinplate industry. For this purpose the Steel Company of Wales was formed in 1947 by four leading companies in the industry—the Guest Keen Baldwins Iron and Steel Company, Ltd.; Richard Thomas and Baldwins, Ltd.; John Lysaght, Ltd., and the Llanelly Associated Tinplate Companies, Ltd. These companies pooled certain of their resources, valued at more than £10 million, which included a steel works at Port Talbot and Margam, eighteen tinplate works in West Wales and a sheet mill at Newport.

The plans laid down involved the reconstruction and extension of the blast furnaces, coke ovens and coal and ore-handling plant at the Margam steel works in order to increase the production of pig iron to the required amount. These works at Margam would supply the adjacent new Abbey works, in which would be installed a new 80in continuous strip mill, together with a melting shop and ancillary plant. The two plants were to form one integrated works, which would, when completed, extend for 4½ miles and have an estimated annual steel production of 1¼ million tons. An integral part of the scheme was the laying down of a cold reduction mill alongside the continuous mill at Margam and a second cold mill with a new tinplate plant at Trostre, near Llanelly. The project, which is now well advanced, given suitable raw materials, will be capable of producing each week 15,000 tons of coke and 19,000 tons of pig iron, from which will be produced 30,000 tons of steel ingots. From the steel ingots will be rolled about 3500 tons of rail and railway material and 22,800 tons of steel strip and plate a week. Of this steel strip 7000 tons will be sent each week to Trostre to be manufactured into tinplate, whilst the remainder will be in the form of hot and cold rolled sheet and plates.

Although some time must elapse before the overall plan is completed, the works is already making an important contribution to Britain's production of steel and tinplate. In this and succeeding articles we propose to deal in some detail with the lay-out, equipment and organisation of the works up to their present production stage. The civil engineering side of the project, site preparation, foundations, &c.,

FIG. 1—MARGAM WORKS FROM THE RAIL SIDINGS

have already been dealt with in papers given before the Institution of Civil Engineers by Messrs. D. Lumbard and A. A. Wright and Mr. W. S. Atkins. An abstract of Mr. Atkins' paper was reproduced in THE ENGINEER of April 7th 1950, page 417.

RECONSTRUCTION WORK AT MARGAM

In planning the extensions to the existing Margam works many problems were involved, as it was essential that current production should be maintained. The degree of success with which the work was planned and executed is indicated by the fact that since the work began in 1945 there has been a steady increase in the output of all sections of the plant.

The scheme of expansion necessitated an increase in the capacity of the existing blast furnaces and it was decided to rebuild No. 1 furnace as a 21ft. 6in hearth and Nos. 2–3 furnaces with 25ft 9in hearths. This decision gave rise to problems of even greater magnitude as it then became necessary to plan the site to handle the greatly increased tonnages of raw materials, slag and iron, as well as increases in the volume of gas. This work has now been largely completed and a good impression of the Margam works as they now are can be obtained from a photograph reproduced herewith in Fig. 1.

FIG. 2—NEW COAL WASHERY AND RAW COAL CONVEYOR

The coal and limestone, together with a certain amount of home ore, is brought to the plant by rail and several miles of wagon sidings have been laid down to accommodate the large numbers of trucks handled daily. The bulk of the ore is brought by sea and the new wharf accommodation and equipment installed for its handling will be dealt with later in this article.

The rail-borne coal and ore handling plant, which has been installed by Mitchell Engineering, Ltd., includes two wagon tippler hoists for handling coal and one for ore, and provision has been made for installing a second ore hoist at a later date.

The coal is tipped into bunkers from which it is fed mechanically into a system of belt conveyors leading to the coal washery and coke oven plant. These hoists for both ore and coal have hoisting speeds of 45ft per minute and are built in pairs with a common control room for each pair. During the tipping operation the wagons are automatically clamped and supported on the tippler cradles. Hoisting motors of 80 b.h.p. running at 720 r.p.m. are operated through automatic contactor panels by remote control from the drivers' cabins.

Each wagon is run in turn on to a hoisting cradle set some 18ft above ground level and the gross load is weighed and registered on a dial recorder in the control cabin. It is then elevated to a height of 52ft, where it is automatically tipped for the contents to be discharged into a receiving hopper. The wagon is then returned to a height of 37ft above ground level and by means of a mechanical tilting device is automatically run off on to lines, which carry it over a weighbridge, where the tare weight is recorded. Beyond the weighbridge the empty wagon runs up a reversing gradient and is returned to the sidings through an automatic switch point. The hoisting cradle safety locking switch is automatically operated by a wagon running off and the cradle is returned to the lower level for reception of the next loaded wagon.

Each coal tippler has a 50-ton steel bunker fitted with vibrator feeders at the bottom outlet, each of which passes coal on to its own double-screw mixing conveyor, feeding in turn on to a centrally placed belt conveyor. To prevent dust emission from the coal at this point and others in the handling system, a small amount of water is fed into the screw mixer. A magnetic valve, which operates the water supply to the wetting sprays, automatically shuts off the supply when the bunker is empty, or when the plant is stopped such as by a failure in the electrical supply.

Two 42in belt conveyors, in a totally enclosed gantry, and running in series, convey the coal to the new washery, the total length of the two conveyors being 1040ft, with lifts of 65ft and 45ft, respectively. Limestone is fed from the sidings to the furnaces by a belt handling 450 tons per hour, which has a speed of 230ft per minute and a lift of 28ft.

In the photograph we reproduce, giving a general view of the Margam works from the raw materials reception sidings, the tipplers to be seen in the foreground are supplying coal to the washery and preparation plant and the tippler and conveyor belt system on the left are used to take rail-borne ore to the blast furnace bunkers. A new lime burning plant can be seen in course of construction behind the coal tipplers.

When the developments at Margam works were planned it was estimated that the demand for internally manufactured blast furnace coke would be increased from 5800 to 14,500 tons per week. This increase in coke production would involve an increase in the quantity of fully prepared coal carbonised each week from 7000 to 17,500 tons (dry weight). The coal gas made and treated in the course of carbonisation would increase from approximately 550,000 cubic feet to 1,375,000 cubic feet, and the quantity of by-products to be recovered from the gas would increase in the same proportion.

THE COAL WASHERY

As the existing coal washery and preparation plant was quite inadequate it was decided to build additional new coke ovens with a new washery and coal preparation plant for dealing with the entire supply of coal required and to build a new coke screening and by-product plant to deal, respectively, with all coke and gas from both the existing and new ovens. The new coal washery is illustrated in another of our engravings (Fig. 2) and the conveyor feeding the raw coal into the wash-boxes at one end of the building can be seen in the right foreground. The plant in this building was installed by the Coppée Company (Great Britain), Ltd. Incoming coal is fed to two wash-boxes arranged in parallel, but it can, if necessary, be by-passed direct to the washed coal bunkers.

Each of the automatic "Baum" type wash-boxes is able to deal with 175 tons per hour and in them the shale level at both primary and secondary ends of the box is automatically controlled by a weighted float resting on the shale bed. Shale discharged from the box is conveyed to a reinforced concrete storage bunker of about 185 tons capacity and is afterwards loaded into lorries for disposal.

From the wash-box the coal is passed over four sets of reciprocating screens for the removal of water and slurry and dewatered coal is transferred by chutes to a conveyor, which delivers by means of a reversible cross belt on to either of two shuttle conveyors feeding the washed coal storage bunkers.

Thirty reinforced concrete storage and draining bunkers for the washed coal are each of 200 tons capacity. Each of these bunkers has a draining table outlet so designed that the feed of coal can be accurately regulated. Each feed table has its own separate motor drive through a gearbox and each of the two rows of fifteen bunkers has its own belt conveyor, capable of carrying 250 tons per hour normally, but up to 315 tons per hour maximum. These two 42in belts feed on to a cross conveyor, which delivers to the main conveyor for taking clean coal to the crushers.

In a crusher house separate from the washery there are three 180 tons per hour throughput swinging hammer pulverisers. After crushing the coal is fed on to a conveyor system, which can deliver either to the bunkers of the original coke ovens or to that of the new ovens.

The slurry handling and preparation system of the washery is very complete and can be used either to flocculate or to froth float the slurry. Underflow from the dewatering sieves is all collected in a slurry basin, where the coarser particles settle rapidly. Three slurry pumps, each capable of delivering 3000 gallons per minute, withdraw the coarse slurry from the basins, plus sufficient water containing the fines so that the total withdrawal of slurry is at least equal to the amount being produced. This system of slurry basins with pump withdrawal has been adapted to supersede the slurry tower. The slurry is delivered either to a 50ft diameter thickener, where it can be flocculated and recovered, or to three Coppée vacuum flotation machines, each capable of handling 25 tons per hour of raw slurry.

COKE OVENS AND BY-PRODUCT PLANT

The original coke oven plant, built by Simon-Carves, Ltd., in 1939/40, had to be enlarged from 1000 tons to 2500 tons per day of coal input capacity. This installation consisted of fifty-four compound underjet ovens with a semi-direct by-product plant, which was partly new and partly retained from an earlier installation. Under the expansion scheme Simon-Carves, Ltd., built ninety new ovens, together with a new coke handling and grading plant delivering coke direct to the furnace bins. In addition, a completely new by-product plant, designed by the same firm, takes the gases from the old and the new ovens, plus a future extension of fifteen ovens. The old recovery plant has been entirely scrapped.

The ovens, which are of the compound "superjet" type, are built in six blocks of

fifteen ovens each, all in line with the original units. Sixty of these ovens, together with a new coal service bunker of 2000 tons capacity, which has been erected to serve them, can be seen in Fig. 3. The bunker receives coal from the adjacent washery and blending plant and is the first of its kind in this country to be fitted with reciprocating feeders in place of the conventional mouthpieces. These feeders draw the coal from longitudinal slots and deliver it to belt conveyors, which in turn feed the charging car. The bunker slopes are lined with glass and the coal can thus be drawn easily and freely without the formation of stagnant pockets. The ovens are each 44ft 7½in over the sole, with a 12ft 6in chamber height and a 17½in (hot) chamber width, with a 2½in taper. The charge is 16·15 tons of wet coal.

Rich gas is fed to the battery through the customary underjet burners, located in a basement formed by the concrete sub-structure, on which the refractory work is built. Air is supplied to the battery at the regenerator inlets under natural draught, but provision is made to supply this air under pressure through steel nozzles fitted in pipes embedded in the top decking of the superstructure. Similar steel pipes embedded in the same way are supplied for the delivery of lean gas through nozzles to individual compartments of the regenerator. The subdivision of the regenerator fillings into compartments feeding individual heating flues gives precise control of combustion conditions for each flue, whether fired by rich or lean gas.

The self-sealing oven doors have easily renewable sealing frames. At present there is only one ascension pipe per oven but all gas-collecting mains are designed to allow installation of duplicate ascension pipes and cross-over mains in the future.

Two sets of machines are provided for the oven batteries, each consisting of a combined ram, leveller and door extractor machine, a coke side door extractor and trailing coke guide, a coke car locomotive and coke car and a coal charging car. A coke guide transfer and repair station is arranged between the new and old batteries. A new quenching station, built at the outer end of the battery and to be seen on the left-hand in Fig 3, forms an addition to the existing quenching station.

For safety in oven operation there is provided an electronic ram and coke guide alignment unit. It incorporates a light-sensitive cell and associated amplifier mounted on the ram machine and a projector fitted to the coke guide. In operation it is not possible to push an oven until both machines are in correct alignment and the guide is ready to receive coke.

After it has been quenched the coke is deposited by the car on to a new 280ft long wharf, at the bottom of which it is released through hand-operated gates to fall on to a conveyor belt. This 124 tons per hour wharf belt is 460ft long and discharges on to a screen conveyor, which feeds on to a reciprocating primary screen designed to remove all coke above 4½in. The large coke goes to a cutter, in which it is reduced into pieces 4in or under. All coke below 4½in is taken straight from the primary screen to the secondary screens, where it is joined by that from the cutter. There are two double-deck reciprocating secondary screens working in parallel, each having a capacity of 60 tons per hour. From these screens all coke above 1½in goes to the furnace conveyor or to a boom loader, whilst the 1½in to ⅜in coke goes either to the furnace conveyor or to the domestic screens, where it is joined by all coke below ⅜in. In the domestic screens the coke is divided into grades suitable for the domestic market and the grades of coke are stored in three 30 tons capacity bunkers, each of which is fitted with a rail-loading chute.

The coke stocking plant is arranged to take run-of-oven coke to the stocking ground and also to collect and return it to the screens. It consists of a reversible stocking conveyor, which runs at 225ft per minute and extends for 800ft to a 100-ton reinforced concrete storage hopper. From this hopper the coke is fed to the skips on an aerial ropeway, which leads to a stocking field, where 80,000 tons can be stored. For reclaiming the coke from the stocking field, a mechanical shovel is used to load the ropeway skips, which return the coke to a 20-ton reinforced concrete reclaiming hopper. From here a short variable speed belt conveyor with a speed of 40ft, 60ft or 80ft per minute (equivalent to 12, 20 or 30 tons per hour) takes the coke to the reversible stocking conveyor discharging on to the primary screens.

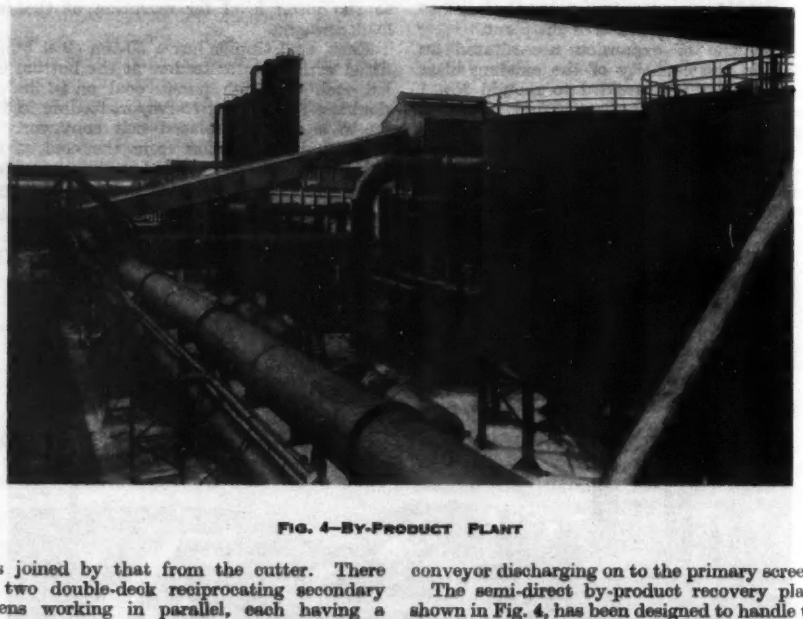


FIG. 4—BY-PRODUCT PLANT

The semi-direct by-product recovery plant, shown in Fig. 4, has been designed to handle the gas from 2750 tons of coal per day, which is the maximum capacity of the coke oven plant, including the future extension.

There are six vertical water-tube primary condensers, each having a cooling surface of 22,000 square feet, followed by two turbo-exhausters, each capable of handling 1·375 million cubic feet of gas per hour. One of the condensers and one of the turbo exhausters are installed as spare units. They are in an exhauster and compressor house integral with the condenser substructure and pump house.

The exhausters deliver to five Simon-Carves-Ferranti electro-detarrers, each 9ft 6in diameter, where final traces of tar are removed before the gas enters one of two saturators. These saturators are made throughout of Monel metal without linings and each is fitted with a gas heater and a Monel metal acid catch. Salt is pumped from the classifier at the base of the saturator to a Monel cone, which feeds a horizontal centrifuge. The ammonium sulphate is taken by belt conveyor from the centrifuge to a dryer, from which it is elevated to a storage hopper for weighing and bagging.

Following the saturators in the gas stream are two secondary coolers, each 14ft inside diameter, 118ft high, the second having a naphthalene extraction section in which the gas is washed with warm benzolised oil before final cooling prior to benzole removal. Four benzole scrubbers, arranged in series, are each 15ft inside diameter by 102ft high and comprise mild steel riveted shells packed with timber grids. Two stripping stills, each of 7000 gallons of wash oil per hour capacity, produce crude benzole for disposal, without refining.

The naphthalene is washed out of the benzole-free gas in two scrubbers in parallel, which reduce the naphthalene content to 2 gr. per 100 cubic feet in the summer and to 1 gr. per 100 cubic feet in the winter. The naphthalene residue, after distillation of the wash oil, is settled in trays and finally centrifuged.

The booster capacity is sufficient for the total gas production of 32·8 by 10^6 cubic feet per day and the gas can be pumped either to the Margam or the Abbey works or to the mains of the Wales Area Gas Board, as required.

(To be continued)

FIG. 3—COKE SIDE OF TWO NEW OVEN BATTERIES

Metal Economics

No. II—*(Continued from page 536, October 26th)*

WE reproduce below the paper on "The World Supply of Non-Ferrous Metals," read by Mr. R. Lewis Stubbs, in London on October 17th, during the general discussion on "Metal Economics" organised by the Institute of Metals.

As our chairman has said, the present shortages of non-ferrous metals have led to much speculation about the future. Some experts predict that some of the non-ferrous metals are always going to be in short supply in future; others go so far as to say that they are running out and that we may have none of some of them in fifty or sixty years' time. In my paper I try to assemble the facts on which any forecast must be made. I am going to talk about copper, zinc, lead, tin, aluminium and magnesium.

Current Shortages

Since our present shortages have caused all our worries and have led to a certain confusion of thought on the subject, I should like to begin by analysing their extent and causes so that we may clear the air. Authoritative figures of production and consumption in the free world have been issued by the Economic Co-operation Administration in Washington.

In the case of copper the consumption over the three years 1948, 1949 and 1950 was 125,000 tons below production, but when you take into account the purchases for the stockpile you get a total deficit of 295,000 tons. In zinc the position is somewhat similar; the consumption was 97,000 tons below the production over the three years, but on taking account of stockpiling there is a deficit of 78,000 tons. In the case of lead and aluminium the production exceeded the consumption even when stockpiling is taken into account, but in tin there is a deficit of 7000 tons when you take into account stockpiling. During those three years the United States Government stockpiled some 5 per cent of the world's total production of copper and zinc, 8 per cent of that of lead and no less than 21 per cent of the total production of tin. What has happened, of course, is that stocks previously in the hands of producers and consumers have in effect been transferred to the American stockpile and that is the cause of our present shortage, or has certainly brought on the present shortage.

The mine production for these three years, 1948–1950, is also known. The smelter production exceeds the mine production in the case of copper by 23,000 tons. There was a surplus of mine production over smelter production in the case of zinc, but some of the mine production was used to make zinc oxide and lithopone and therefore there was a deficit of over 100,000 tons. In the case of lead there was also a deficit of about 100,000 tons. Nevertheless, I do not think that those deficits are sufficiently great to change my contention that the shortage was brought on by the American stockpiling policy.

Various opinions are held about the policy of stockpiling, but most people will agree that the present shortages would be solved if the American stockpile were placed on the market now. All the same, most of us would be very glad if we had the stockpile here, and we ought not to be too critical about the policy. Producers, on the other hand, must view stockpiles with a certain amount of apprehension, lest they should at some time be used for other than strategic purposes. Recently the United States Government sold some of the tin in its own stocks (but not from the stockpile) to general consumers to bring down world prices and more recently some of the copper in the American stockpile was sold when there was a strike at producers' works. I should not think that that pleased the unions very much!

Since 1950 the position has changed a little and now I think that it is our defence requirements which are throwing production and consumption out of balance. Stockpiling has been at a very much lower rate this year and will probably be smaller again next year.

The Long-Term Demand

I should like to turn to an examination of the trends in consumption before seeing how we might overcome the present shortages. In a general way it is easy to determine roughly the requirements for the next few years but, as our president has said, it is very much more difficult to determine the consumption trends further ahead. Recently we have been going through a period of accelerated industrial activity. The standard of living has been rising throughout the world and there has been an increase in world population. Trends in production over the last fifty years show that there has been a steady upward trend despite fluctuations. Copper has come up very considerably and only in the case of lead does the peak appear to have been passed in the middle 'twenties. The most spectacular rise has been that of aluminium.

Price has also a very important influence on the consumption of metals, though it is overshadowed just now by shortages. Between the wars there does not seem to have been any significant relationship between price and output, the slow downward trend in prices corresponding with the slow increase in the value of money as measured by the wholesale price indices. This trend was maintained right through the whole period between the wars. Prices began to move upwards again at the outbreak of war, and continued to do so until the middle of 1948, when there were some minor fluctuations. Prices have again started to mount, the falls being arrested by the new demands which occurred after the start of the Korean war. Between the wars the relationship between the price of the different metals never changed significantly, but aluminium is now very much cheaper than the other metals by volume, and I think that this is very important, because it seems to me that the price gap between the old and the new metals may even widen in the future. The average costs of copper, zinc and lead may be expected to rise when new production is brought in, since it will mean the use of lower grade ores; but with aluminium and magnesium there are abundant supplies of ores, and new production will really depend on increases in the supply of electric power. The prospects are good in many parts of the world. In other words, aluminium looks like competing favourably in the future on a cost basis.

Magnesium is another metal which is likely to be very important in the future, both for its properties and for its comparatively low price. At present its price per pound in the United Kingdom is about twice that of aluminium, but its specific gravity is only 1·7, compared with 2·7, so that the price per cubic foot is not much greater. Incidentally, the price of magnesium is now much higher here than it was a year ago, probably because of the sudden increase in the demand as a result of rearmament. In the U.S.A., however, the price is still only 35 per cent above that of aluminium. At the end of the war huge stocks of magnesium were left over, and production virtually ceased and has just started again.

From all this it is clear that we are now faced with an entirely different pattern of consumption from that which prevailed between the wars, and that more and more non-ferrous metals are becoming available for general use. The indications are that, as consumption grows, aluminium and magnesium will take an increasing share of it, and thus the rise in the consumption of copper, zinc, lead and tin is likely to be less steep than the rise in industrial production throughout the world. This has already occurred in the United Kingdom where industrial production from 1946–50 rose some 40 per cent, but the consumption of various metals rose by very different percentages, e.g., aluminium 56, zinc 13, copper 6 and lead 3, and tin consumption actually fell. Hitherto, a certain conservatism has caused the older metals to be chosen for many purposes because they have always been so used. Now, however, aluminium is getting a tradition of its own which will tend to increase its use at the expense of the older metals, and the same applies in a lesser degree to magnesium. The fact is that there are perhaps many applications in which the older metals could be replaced by aluminium or magnesium, and the extent to which the switch-over will take place will depend mainly on the price and availability of the older metals. These, however, may feel the pressure from aluminium rather less because the latter has a competition of its own with steel which may divert its supplies.

Titanium is another metal for which a great future is predicted, though it seems likely to compete more with steel than with the non-ferrous metals. Plastics have also become an important competitor in the metals field and have made some inroads, and may make big inroads, into the non-ferrous metals field in the future.

The World Resources

I should now like to turn to the world resources. Before considering the resources of ores which are available to meet future requirements, some general observations on world resources are, I think, worth making. First, up to the present certainly not more than two-thirds of the land surface of the earth can be said to have been explored for minerals. While it is probable that the remaining third will be found to contain less mineral wealth in proportion, there must nevertheless be huge unknown resources still awaiting location. Most of the great discoveries in the past twenty years have been made in the so-called explored regions, and these will no doubt continue. It must not be forgotten also that the period between the two world wars was one of overproduction, when there was no urge to seek new ores.

Another factor which has an important bearing on the estimation of world resources is that in the last twenty years important new methods of locating ore bodies have been introduced. Although science has not yet succeeded in evolving any method of locating really deep deposits, the scientific aids available to prospectors now include the airborne magnetometer and field methods, such as soil micro-analysis, and the analysis of plants known to take up metals in easily detectable quantities if they are present to an abnormal degree in the soil as a result of the proximity of ore deposits. In these various ways, ore bodies not revealed by outcrops are successfully located.

The present high prices have led to much more active prospecting, the results of which can be seen in the large number of new mines and workings now being opened up, and here it is to be noted that these ventures have been based on work begun when prices were much lower than they now are. Another result of the price stimulus will be the exploitation of poorer ores than those previously worked, and, as extraction techniques improve, the amount of such ores increases. The mining of ores at lower levels will also prove economic. Many mining companies know quite well what additional reserves can be reckoned on as prices advance. Incidentally, not all producers welcome high prices, since in the case of the low-cost mines the increased profits can bring on labour troubles and perhaps the threat of nationalisation.

It is often said that all the accessible deposits are now being worked, but I do not know on what that is based, because there are few places less accessible than the copper belt in Northern Rhodesia, or Mount Isa and Broken Hill in Australia, and Flin Flon in Canada, or, at least, they were very inaccessible when the deposits were discovered; they have, of course, been made accessible since.

I now propose to deal with each metal

separately and to examine the estimates of resources made by different experts to see just what the prospects are.

Aluminium.—I think that everyone agrees that there is plenty of aluminium in the world; in fact, it has been said that aluminium constitutes 8 per cent of the earth's crust. It is mainly present in the form of clays and other silicates, which, though they can be used as ores, are not so used at present; only bauxite being mined on a large scale. Bauxite, however, is found in large quantities in many parts of the world and there is no immediate prospect of other sources having to be used. As I said earlier, the only factor likely to limit aluminium production is the availability of electrical power, the cost of which constitutes about 60 per cent of the present cost of the metal. The future of aluminium is very closely linked with the development of hydro-electric power or other large-scale plants for producing electricity cheaply. With regard to the production of aluminium it is estimated that the total world output in 1951 will be 15 per cent higher than in 1950 and by the end of 1953 as much as 50 per cent higher than it is to-day. A dozen new smelters are in course of erection in different parts of the world, the largest being in North America.

Magnesium.—Magnesium is in a similar position to aluminium in that it is very plentiful and is believed to constitute 2 per cent of the earth's crust. It is obtained from deposits of magnesite and dolomite and from brines and sea-water and so is virtually unlimited. Its production generally requires electric power, though thermal processes are also used. The U.S.A. consumed about 20,000 tons of magnesium in 1950 and expect to use some six times this amount annually by 1960. The production is being increased accordingly.

Copper.—Authoritative figures for the reserves of copper are difficult to obtain. The total "officially reported" in the Year Book of the American Bureau of Metal Statistics for 1951 is approximately 60 million metric tons, but this does not include a number of the largest mines, both in America and elsewhere. From recent company reports it is evident that approximately 7·9 million tons should be added to the above figure, but even this fails to include many important mines for which no reserves have been published, but which may be estimated at about 16 million tons. In other words, it is safe to assume that there is a reserve of at least 100 million tons of copper at present, or sufficient for at least forty-four years at the current rate of consumption.

Prospecting for fresh deposits is continually going on and valuable "finds" are not infrequently made; it should be remembered, for instance, that the enormous ore-bodies of the North Rhodesian copper belt were unknown until about a quarter of a century ago and other deposits of comparable magnitude may well be discovered in years to come. It is apparent, too, that as methods of extraction improve, grades of ore previously regarded as uneconomical will become workable, and the development and continual improvement of the froth flotation method of concentration is a dominating factor in this direction.

For these and other reasons there seem to be no grounds for supposing that supplies of copper will be insufficient to meet the essential requirements of an expanding economy for many years to come.

Zinc.—With zinc we have more estimates of the resources than with most of the other metals. The latest and most authoritative survey was given in a paper by Dr. K. C. Dunham, in 1948, dealing with reserves of ore of lead and zinc. In quoting his figures, Dr. Dunham observes that a high proportion of the estimated reserves mentioned falls within the possible and speculative (inferred) categories; nevertheless, the estimates are made by experienced mining engineers and are not flights of fancy. Other reliable estimates were made by Mr. W. R. Ingalls in 1931 and by Mr. W. P. Shea in 1940 and 1947. The figures are very interesting because these reserves appear to grow with each new estimate. In 1931 the estimated reserves were 24·5 million metric tons; in 1940 they were 39 million; in 1947 they were 57 million and for 1950 they were given as 65 million tons. In other words, the reserves have been growing much more rapidly than the rate of consumption.

Discoveries of new zinc deposits are being made in many parts of the world and are far too numerous for any detailed mention. The most important are perhaps those in Canada and French North Africa. In Canada, the new Barvue mine alone expects to produce 4000 tons of ore per day and surface drilling has already outlined 17 million tons of ore.

The exploitation of poorer ores, as well as of the vast heaps of slag from lead blast-furnaces, which lie all over the world, will be at present prices, assuming that they continue, a further source of metal. Thus, at Bergamo, in Italy, a new smelter is being built especially to deal with the abundant local supplies of poor grade ore.

Lead.—In the case of lead there has so far not been any overall world shortage, though there have been shortages locally in some countries, which in future may become more serious, particularly if the shortages of zinc and copper continue. Since zinc and lead are generally found together, the new mines referred to under zinc will provide an important addition to the reserves of lead. Shea and Dunham have both made estimates of the world reserves of lead and these correspond very well. The estimated reserves in the year 1947 and in the year 1950 both amount to about 32 million tons.

Tin.—Since the end of the war the production of tin has been in excess of consumption, the shortages experienced during and immediately after the war having allowed substitutes to become well established. It has been said that the resources in Malaya, from which about 35 per cent of the world's tin is obtained, are rapidly being depleted, but the real trouble is that prospecting has been prevented by the local disturbances. Good reserves are known to exist in Indonesia, the Belgian Congo and Bolivia.

In general, the reserves of the principal non-ferrous metals seem to vary according to likely future demands, with aluminium at the top of the list and lead at the bottom.

Overcoming the Present Shortages

Having shown that the long-term supplies should cause little anxiety, we ought now to turn to the problems of the present shortages, where the position is much less clear. I think it is evident that they were brought on by stockpiling and are now being aggravated by the demands for defence. Furthermore, as always, every shortage seems to create an extra demand. The present situation seems likely to continue for some time, and to be followed by a fairly heavy demand for civilian consumption for an indefinite period. All this uncertainty affects the flow of investment towards the development of mining and smelting, and the time-lag between a new mine or smelter and actual production must always be allowed for. Moreover, it must be realised that this is almost the first time, apart from war conditions, when metal consumption has exceeded production, and producers naturally fear a sudden return to the former state of affairs. Nevertheless, many new mines are being opened up, and the *Engineering and Mining Journal* mentions no less than fifty new copper, zinc or lead mines as having been opened during the first six months of this year. I believe that the real shortage is only a few per cent, and is likely to be over fairly soon; but we are always faced with the difficulty that we cannot determine the extent of the demand so long as consumption is limited by the shortage of metal.

Before considering our own prospects I think that it is interesting to see what has been happening to consumption in the leading countries since the shortage began. What has really happed is that consumption has risen in almost every country with the exception of the United Kingdom and the U.S.A. In other words, the countries with the biggest purchasing power have felt the shortage more acutely than the others. The causes of this situation seem to me to be fairly clear. First of all, there is the rapid growth of the fabricating industries in the exporting countries such as Canada and Australia. In Australia, the home consumption of zinc has been encouraged by the fixing of an exceptionally low internal price. More recently, the Canadian fabricators have been able to buy metals more cheaply than the users of Canadian metals in this country. The same price differences can be seen in other exporting countries. This, of course, is not a new trend, but it is being given further encouragement now that the exporting countries find that money is losing its value and often does not command the equipment and machinery which they need.

Secondly, planning and control have become features of economic policy both here and in the U.S.A. In both countries efforts have been directed towards keeping the price of metals down, and recently even the U.S.A., with its colossal dollar purchasing power, has found itself outbid for foreign ores simply because it could not turn the ores into metal which it could sell at the home price.

The wholehearted determination of America and ourselves to solve our difficulties and those of the free world generally by international planning and control is shown by the setting up of the International Materials Conference, which has the object of ensuring the fair distribution of the raw material resources of the world. Here it may be remembered that previous schemes for the international distribution of metal have seldom proved successful, and it remains to be seen whether the threat of aggression may make the chances of success better now. If the International Materials Conference allocation scheme should fail, the U.S.A. may well resort to buying for its armament needs at higher prices in the open market. This, in turn, might lead to a general resumption of free trading in metals, and possibly to the weakening of the present arrangements whereby we and the U.S.A. are able to get good supplies of metal more cheaply than most other countries.

The loss of the free market means that the planners have now to decide for what purposes metals or their substitutes are to be used. In any case, the pattern of control and planning seems likely to last for some time, and the prospects of an early return to free markets are rather remote. It is therefore pertinent to consider what others are doing and what we might do to ensure our supplies under these new conditions.

For a start, it is worth observing that the increase in production has been mainly in the dollar areas. In tin most of the production is in non-dollar areas, but even here the dollar area production has increased, while in aluminium the increase has been tremendous in the dollar area. In other words, nearly all the new production in the last ten years has been in the dollar area.

It seems to me that there are three ways in which we might consider improving our present position: (i) by placing long-term contracts, (ii) by encouraging production in non-dollar areas where we may expect to enjoy a first call on new output, and (iii) by maintaining and fostering ventures with headquarters in London.

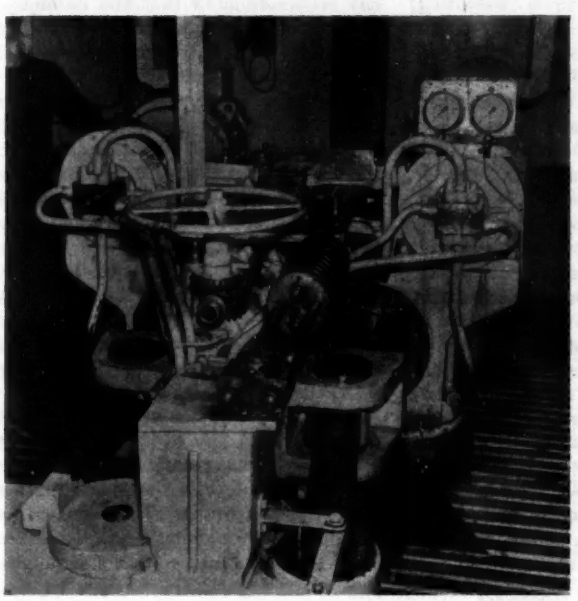
We and the U.S.A. have already placed long-term contracts, often accompanied by loans, a condition of the loan being the repayment of the money in metal arising from the new production. An outstanding example is our arrangement with the Canadian aluminium producers.

Before applying other incentives here, however, our taxation laws would appear to need overhauling, since at present they seem to be a serious drawback to London-based mining companies, which have tended to remove their headquarters elsewhere in recent years. However equitable our mining taxation may be compared to that imposed on other United Kingdom industries, it falls far short of the practice in other countries, and that is the real criterion. Not a single mining company of any size has been floated in the United Kingdom since the war, and it seems certain that none will be under present conditions.

Steering Gear for the Train Ferry "Saint Germain"

THE special loading and unloading arrangements which are necessary for the safe transit of passenger and goods trains from ship to shore make it essential that a train ferry has exceptional manœuvring qualities. The "Saint Germain," which was described in THE ENGINEER on September 14th, is the latest vessel to enter the cross-Channel service between Dover and Dunkirk, and was built for the French State Railways by the Elsinore Shipbuilding and Engineering Company, of Denmark.

At the Dover end the vessel has to enter an impounding lock to effect a shore connection, and to do this calls for prompt rudder action and close control of the steering gear. On entering Dover, the ferry swings round and proceeds stern first up the harbour, turning to starboard to enter the lock, which was specially built for the service, and which is equipped with a pumping station so that water level can be adjusted to suit the height of the loading apron. At Dunkirk the ship passes through a sea lock into the harbour, and after turning goes astern to the loading ramp alongside a quay. Finger-tip control of the steering is necessary not only at the terminal points, but also for navigation about the banks and tortuous channels off the French coast, and so the steering arrangements received special consideration in the design stage.



AFT STEERING GEAR

Two steering gears are fitted, one for moving the balanced aft rudder and the other for operating the forward rudder, and both the gears, together with auxiliary equipment, were supplied by John Hastie and Co., Ltd., Greenock. Limitation of the space available on board set a problem, but by making special arrangements it was possible to fit the gears within the compass of the restricted space allocated. The aft steering gear, illustrated herewith, consists of a two-ram electric hydraulic unit with rams and cylinders arranged parallel to each other and connected by steel rods to a tiller on the rudder stock. Control of the rudder is effected by two Hastie pattern Hele-Shaw pumps, each driven by an electric motor of 18 h.p. and each pumping unit can exert a twisting moment of 60 tons-feet on the rudder stock, so that the rudder can be moved hard over from port to starboard in twenty-five seconds with the vessel proceeding at full speed ahead. Arrangements are such that both pumps can be operated simultaneously, and provision made for power to be available for carrying out helm orders without interruption should there be a failure of the electrical supply to one pumping unit. The electric motors are provided with automatic starters and on the engine-room platform there is a push button start and stop control.

An hydraulic telemotor, of Hastie's latest pattern, controls the steering gear and consists of a transmitter telemotor fitted in the wheel-house on the forward bridge, and another transmitter, complete with change-over valves, on the boat deck aft. As arranged, these transmitters provide for the control of the aft rudder, through a receiver telemotor, from either position.

The forward steering gear is similar to that operating the aft rudder except that, in this instance, only one electric motor and one Hastie pattern Hele-Shaw pump is fitted. The pumping unit can exert a twisting moment sufficient to put the rudder hard over from port to starboard in twenty-five seconds with the vessel proceeding at its full permitted speed astern. Control is by hydraulic telemotor and the arrangement consists of a transmitter telemotor mounted on the starboard wing of the forward bridge, with the pedestal and wheel arranged for the helmsman facing aft, and connected to a receiver telemotor at the steering gear. In order that the ship can be steered from either side another steering pedestal is fitted on the port wing of the bridge, and this is mechanically connected with the starboard telemotor by a system of universal joints and shafting running in ball bearings. The design of the ship's superstructures and the arrangement of the deck fittings are such that a clear view aft is obtained from both port and starboard pedestals. The arrangement of the telemotor controls is shown in our diagrammatic sketch.

We were able recently to make the double crossing on the "Saint Germain" as a guest of the French State Railways and the Association Technique Maritime et Aeronautique, to observe the steering gears in operation. After leaving Dover the ship was manœuvred with the stern rudder, and it is understood that the diameter of the turning circle when going ahead is 250m and 275m when going astern. These figures illustrate the excellent manœuvrability of the ship, which has a waterline length of 111·8m. At Dunkirk, astern steering was observed and later on the same day the performance of the bow rudder was again demonstrated. The ship went astern a considerable distance and, navigated with the aid of a searchlight, was swung, under starboard helm, directly into the impounding lock.

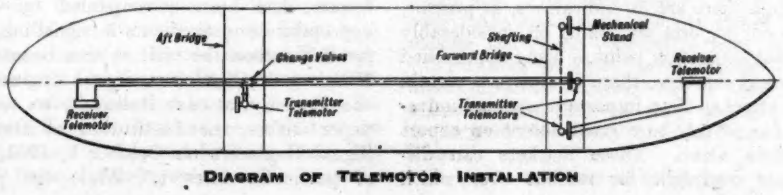


DIAGRAM OF TELEMOTOR INSTALLATION

While the ferry was moored at Dunkirk for unloading and loading ready for the return voyage to Dover, we made a short visit to the Ateliers et Chantiers de France at the invitation of the chairman, Monsieur Lefol. During the visit we spent a short time on board the "Flandre," a liner which the company is building for the Compagnie Generale Transatlantique. As a memento of our visit we were presented with a beautifully illustrated volume which describes the founding of Dunkirk and the development of the city and port. The book pays particular attention to shipbuilding activities and traces the history of naval construction from early times through the centuries to the present day.

Cargo Handling Co-ordination Committee

ON Tuesday, on board the "Wellington," the headquarters ship of the Master Mariners, a meeting was held to discuss the formation of an International Cargo Handling Co-ordination Committee. Preliminary meetings of those interested had already taken place and, as a result, articles of association had been prepared, copies of which were available for discussion. The initial meeting, presided over by Rear-Admiral Mark Wardlaw, was attended by delegates and observers from a number of countries, including France, Italy, Belgium, Holland, Sweden and the U.S.A., and also from the Admiralty, port authorities and many shipping interests in this country. In speaking about the committee, Monsieur X. Le Bourgeois explained its beginnings and the need for investigation into the reasons of port delays. The work of the committee would be to glean from world-wide sources all published knowledge on the subject of cargo handling and then put statistics and a rational analysis before responsible authorities. Continuing, he suggested that the investigation into delays should follow the cargo from the packer through the various means of transport to the consumer and so all concerned would benefit from the knowledge gained. Monsieur Bourgeois said that interchange of ideas and advice would help the packer, the exporter, the shipbuilder and the ship owner to effect an overall improvement in handling cargo and so, by lowering transport costs, reduce the price to the consumer. Those present at the meeting elected an executive committee with Mr. A. C. Hardy as co-ordinator. Following upon some discussion concerning finance and the future programme, the executive committee met to consider an agenda for the next meeting to be held on November 16th.

AERATED CONCRETE FILM.—Last week the Department of Scientific and Industrial Research presented a new film entitled "Aerated Concrete," which had been made by the Building Research Station's film unit. The film showed how aerated concrete, which is a light-weight concrete with high thermal insulating value, is made, and gave illustrations of the application of the material in the construction of buildings. Two main methods of production were demonstrated. There was the aluminium powder process, in which aluminium powder, when added to a wet cement, caused the formation of hydrogen gas bubbles, care being taken to prevent lateral union of the bubbles. The second method consisted of adding a foaming agent to the mixing water and working the cement and sand mixture to produce a light-weight concrete. Blocks made from this material were shown being cured in an autoclave under pressure.

THE ENGINEER

Vol. CXCII NOVEMBER 2, 1951 No. 4997

Contents

PAGE

LEADING ARTICLES—
International Motor Show 560
French Railway Signalling 560

SPECIAL ARTICLES—
Modern Approach to Electrical Machine Analysis., No. IV. (Illus.) 546
Recording Voltage Transients During Fuse Operation. (Illus.) 553
Thirty-Sixth International Motor Show. No. II. (Illus.) 562

Canadian Supersonic Wind Tunnel. (Illus.) 571
Cargo Handling Co-ordination Committee 559
Completion of the Trans-American Micro-Wave Relay System. (Illus.) 572
Electrical Engineering and Research at Queen Mary College. (Illus.) 569
Equipment for the Artificial Illumination of Plants 570
Institution of Mechanical Engineers 567
Metal Economics. No. II 557
Steering Gear for the Train Ferry "Saint Germain." (Illus.) 559
Twenty Cubic Yard Walking Dragline. No. I. (Illus.) 548
Ultrasonic Tyre Testing Equipment. (Illus.) 565
Works of the Steel Company of Wales. No. I. (Illus.) 554
1700kV Impulse Generator. (Illus.) 551

PAGE

LETTERS TO THE EDITOR—
Assessment of Locomotive Performance 561
Hospitals, Institutions and the Engineer 561
Present-Day Locomotive Working 562

A SEVEN-DAY JOURNAL 545
British Cast Iron Research Association
Director of Mechanical Engineering Research
Late Sir Henry Grayson, Bart.
New Government
Training of Operatives
Transport Commission's Research Appointment

NEWS AND NOTES—
British Patent Specifications. (Illus.) 575
British Standards Institution 552
Codes of Practice 576
Continental Engineering News 568
Contracts 574
Forthcoming Engagements 576
French Engineering News 572
Industrial and Labour Notes 573
Notes and Memoranda 574
Personal and Business 574

SUPPLEMENT—Twenty Cubic Yard Walking Dragline

THE INTERNATIONAL MOTOR SHOW

THE thirty-sixth International Motor Exhibition, which ended on October 27th, attracted 373,000 people, about 100,000 fewer than last year's show. But the great public interest in cars still remains remarkable, since there seems to be no prospect yet that the demands of customers at home will be satisfied in the immediate future. In spite of the fact that Britain's car population is suffering from senile decay, so that tens of thousands of cars qualify for the scrap heap (though they do not all reach it) every year, the Socialist Government allocated only 80,000 cars to the home market for 1952, less than in any year since the war ended. Motor industry executives, are therefore, pleased at the recent turn of political events and the motoring community, possibly optimistically, is looking forward to some relief from the burdens which Great Britain's post-war administrations have heaped upon them, and more particularly to a more generous allocation of steel, which would allow an increase of production for the home market. It was possibly this rather optimistic outlook which caused so many thousands of British visitors to flock to Earl's Court, including those who came to witness what has been advertised as "the greatest event in post-war motoring," the reappearance after fourteen years of the rejuvenated Austin "Seven."

To the expert or the student of automobile engineering this year's show was something of a disappointment in so far as it contained a high proportion of models differing only in detail from those seen last year. It would, however, be wrong to attribute the absence of startling or even revolutionary changes in design to a lack of enterprise or to a feeling of complacency in the face of a sellers' market. Under present industrial and economic conditions drastic changes are not likely to occur as frequently as before the war, when firms used to bring out completely new ranges of models each year. The expenditure for developing a new car and for tooling-up for large-scale production is so great nowadays that a basic design has to remain practically static for a period of several years if the car is to be sold at an economic price, though, of course, detail improvements are constantly being made. It is not surprising, therefore, that even those manufacturers who did show new models at this year's show refrained from indulging in bold experiments but concentrated on improving more or less conventional designs. Although there is probably no car at the show which can rightly claim to be years ahead in engineering leadership, progress has been made in detail design, and all British post-war models should now be thoroughly acceptable all over the world whatever the local conditions. But even though it can be understood why design has tended at present to become static, it still remains true that British motor manufacturers, forced to dispose of the main part of their production in export markets, must not allow their products to fall behind in design. Faced with growing competition from Continental manufacturers, British designers must not only keep abreast of engineering progress but should be ahead of current ideas. For it does pay occasionally to be unconventional in design, providing it is done for some clearly defined purpose, and it is interesting to note that the more successful competitors in Continental markets happen to be cars of very unorthodox construction; for instance, the German "Volkswagen" and the Renault. Advanced design, at this year's show, was almost entirely confined to some sports and specialist cars. But though some of these designs were clearly unsuitable for large-scale production, there is no reason to assume that they could not be modified to meet those conditions.

The necessity of complying with overseas requirements and demands has led many of our manufacturers to neglect the design of the more utilitarian type of small car. Though there are no indications, at present, that our exports are falling off considerably or that saturation point is being approached in world markets, there is always a certain risk attached if an important national industry has to rely to a great extent on export markets alone. Those markets can disappear overnight for reasons over which the industry has no control. The recent slump in sales to Canada, caused by the anti-inflationary restrictions on hire-purchase finance, is an example of what can happen. A larger allocation of cars to the home market would certainly give the industry a more secure foundation, providing, and that is the point we want to stress, that the home market can absorb those cars which overseas markets have to reject. Our manufacturers maintain that their order books register almost a million demands. There is no reason to doubt the accuracy of that statement but it has to be remembered that, even if the majority of these orders are genuine, many of them were placed several years back, long before the increased purchase tax, and the general rise in the cost of living had made even a cheap model a luxury, far beyond the purchasing power of the average wage-earner. It has been estimated that the minimum income on which one could satisfactorily run a new car to-day would be about £1250! Though the motor industry may look at the future now, perhaps, with a little more optimism than hitherto, can there be any doubt that money will remain tight for some time to come? The motor industry we think, will find the home market greatly restricted, unless means are found to make cars which cost less and are cheaper to insure, to maintain and to house. The congestion on our roads and the lack of garage and parking space suggest the desirability of cutting down outside dimensions. Is there much point in marketing so many big cars, to carry five or six people in comfort, when the average load is more often two than four? It seems more essential to concentrate on small four-seaters, in which comfort for rear-seat passengers need not be a primary consideration. Cars of this type, weighing probably not more than 15 cwt, would certainly save a lot of raw material and they could be cheaper and more economical to run. The reappearance of the Austin "Seven" as the first British post-war representative of this category of car can, therefore, truly be described as "an event," and we should like to see more motor manufacturers following Austin's example. How the designers are going to solve the admittedly difficult problem of designing the small "utility" car, preferably as something other than a scaled-down version of a larger model, is not here under discussion. There are certainly several possible solutions. What does seem to us essential is that the attempt should be made without further delay.

FRENCH RAILWAY SIGNALLING

THERE is evidence that the French National Railways are making great progress in the equipment of their lines to suit modern traffic. The electrification of a long stretch of the former P.L.M. main line, carrying a heavy traffic from Paris southwards to Switzerland and the Mediterranean resorts, has been accompanied by some appropriate improvements in signalling, and for this reason the visit to this country of Monsieur J. G. Walter, Signal Engineer of the French National Railways, to read a paper before the Institution of Railway Signal Engineers on October 3, 1951, was of particular interest. While the paper

itself covered a wide field, and was prepared so as to present a general picture of French signalling methods in block working and interlocking as they are being applied now in areas requiring new equipment, that part which was perhaps of the greatest interest concerned recent developments in the use of all-relay electric interlockings, since these have their points of strong similarity to certain recent British installations, though in other respects the differences are many. Generally, the French railways have for many years been partial to the route system of interlocking, employing mechanical or electrical combinators to control the setting up of routes without the need for a large number of levers in the locking frame. These combinators have the inherent advantage of providing in their very mechanism the necessary interlocking between conflicting routes, in much the same way that the electric sequence switches do in the all-electric interlocking installed at Doncaster, Eastern Region, which we described in our issue of January 21, 1949. More recently, however, the French National Railways have applied the principle of relay interlocking to accomplish, with circuits, all that the combinators of earlier plants achieved, and it is to these latest installations that we wish particularly to refer. The system appears all the more noteworthy in view of Monsieur Walter's assertion that it represents the future French standard wherever it shall prove necessary to install power signalling. We mention this point with special emphasis, because both here and in America there have been very few signs that finality in power signalling methods was even on the horizon, let alone actually attained.

Recent French installations on the former P.L.M. line are of interest as much in the operational facilities provided as in the technical details of their accomplishment. At Montereau, for example, there were originally five mechanical signalboxes containing locking frames of 30, 36, 39, 100, and 120 levers respectively, and requiring in all seven signalmen on each shift. These have been replaced by a characteristically compact route relay interlocking controlling 350 routes operated from a console no more than 12ft long. It was considered unduly expensive in cabling to connect each individual function by its own wires to the signalbox, and so the interlocking area was split up into sections and each operated as a coded remote control interlocking, on the lines of a C.T.C. plant, connected to the central control machine by a few conductors over which the codes for control or detection of the ground apparatus are transmitted. This arrangement has proved so successful that it will be used in future, not only for large interlockings covering considerable areas, but also, to quote Monsieur Walter, "where a few routes only are involved, in places where there are other and older arrangements in service, less perfect and costlier." As an example he instanced a new interlocking of only sixteen routes at the Gagny spur junctions connecting the Grand Ceinture line, of Paris, with the main line of the former Eastern Railway. This was put into service in November, 1950.

The installation that to us appears of the greatest significance, however, is that of the double-line C.T.C. plant between Blaisy-bas and Dijon. During the night headway between successive expresses in the procession of sleeping car trains from Paris is relatively short, but the timetable provides that while the southbound line is very busy the northbound line is almost devoid of traffic, and vice versa. Accordingly arrangements were made to signal both lines for either-directional running, so that during the two peak periods in the night both running lines could be used for northbound or southbound traffic, as the case might be. The section, 16 miles long, is rendered doubly difficult for northbound trains, as the gradients are heavily adverse, and sleeping car expresses often loading to more than 650 tons are apt to take longer than normal to clear the block sections. The provision of C.T.C. affords the utmost flexibility in operation, enabling freight trains to be kept on the move at the height of the passenger peak period, and an economy and efficiency in general operation due to the centralised control. In this installation extending over 16 route-miles there are thirty-eight pairs of electrically operated points, and fifty-three colour light signals. Between the two extremities, at Blaisy-bas and Dijon, there are four intermediate stations at which train movements are remotely controlled by the C.T.C. operator. While this installation constitutes what is possibly the signalling "highlight" among the notable new works on the P.L.M. main line, the close co-ordination between traffic requirements and signalling provisions is generally apparent, and from all accounts the resulting punctuality of the new electrically operated service is remarkable. It has many times been said that modern signalling is one of the most potent instruments an operating man can have for the rapid and punctual handling of heavy traffic. In France it would seem that this facility is being exploited to the full.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ASSESSMENT OF LOCOMOTIVE PERFORMANCE

SIR,—Such evidence as I have hitherto been able to find does not support Dr. Tuplin's assertion—qualified, it is true, by the word "seem"—that the L.N.E.R. "A.4s" normally found the King's Cross to York timing of the "Coronation" "a shade too tight."

For example, on her first run, in July, 1937, the "Coronation" was quite easily handled by "Commonwealth of Australia," and York reached 1½ min early. On two trips during the next week, before experience had been gained in the working of this unusual turn, "Dominion of Canada" did equally well, and was timed to arrive at York 1 min and 1½ min early.

In 1938, observers at Newcastle reported "Coronation" right time or early on 80 per cent of the journeys made between July and November. For one complete month of this period no arrival was late.

In 1939, Newcastle observers reported the train twice late during April and May, once by 1 min only. Many arrivals were 1 min to 4 min early. About this time, "Golden Plover" was making thirty-nine consecutive trips on the "Coronation," of which twenty-five were in the down direction. Twenty-one of these were reported right time or early at Newcastle, fifteen were 3 min early, and one 5 min before time.

It has to be borne in mind, however, that during the winter months "Coronation" tared 279 tons only.

I rather suspect that inability of the "A.4s" to work the down "Coronation" to time has its basis in legend rather than fact.

JOHN D. MUNNION

Chelmsford, Essex, October 20th.

HOSPITALS, INSTITUTIONS AND THE ENGINEER

SIR,—Your issue of October 19th (page 490), reporting the recent presidential address of the president of the Institution of Engineers-in-Charge, Mr. Chalmers, will have been read with interest and a measure of concern by those most deeply anxious for the success of the hospital service. It reports the president as having criticised, *inter alia*, "the practice of Hospital Boards in putting an architect in charge of maintenance of hospital premises," as claiming that "the architect's distinctive function concerned with the planning and æsthetics of buildings has practically no application to maintenance," and as suggesting that there are regions where, for advising upon engineering maintenance proposals submitted by Hospital Management Committees for approval, "the most senior engineer available at Regional Headquarters is a comparatively junior assistant in the Architect's Department." Much truth yet much that could be prejudicial within the Hospital Service to the good relationship of the closely allied professions of architecture and engineering appears in this address which condemns so forthrightly the present arrangements for carrying out both engineering and building maintenance and new work.

Mr. Chalmers is an engineer of distinction and experience, who is justly proud of the work for which he was responsible whilst a senior engineer to the London County Council, and who feels that in the system he then knew there somehow (albeit a little vaguely) lies the pattern of the system he would like Regional Hospital Boards and their Management Committees to adopt. If it were possible for the joint views of the architectural and engineering professions to be given they would doubtless sound a more harmonious note than the somewhat strident tone of Mr. Chalmers' criticism of architects. Be that as it may, his statements cannot be suffered to pass without a comment from two colleagues on the staff of a northern Regional Hospital Board—its architect and its engineer. The architect has known something of the operating of engineers on the staffs of county architects and as a temporary military "engineer" has himself led a team of architects and engineers in the construction of hospitals for 17,000 patients. In 1949 he nevertheless advised his Board to appoint a Regional Engineer. The engineer has had thirty-two years' unbroken hospital service, including Colonial appointments, years of experience with an association of local authorities covering Wales and the National Health Service as it now is. Both realise, therefore, something of the complexity of the problems Mr. Chalmers has discussed, but has left unsolved—problems of professional relationships and inter-related responsibilities, of unified or divided control, centralisation or local autonomy, distances and duplication and, all too often, of self-interest, fear and distrust.

The president's address contains this paragraph:—"If Regional Boards wished to combine and co-ordinate engineering and building functions in one department, they would have been better advised to make the Regional Engineer the head of that department. For, whereas the architect's supervision of engineering is purely nominal, the engineer is no stranger to structural design and maintenance, and could very well undertake the building maintenance, possibly with a building surveyor's

assistance. The architect's distinctive functions concerned with the planning and æsthetics of buildings have practically no application to maintenance, and consulting architects could be engaged for new building works. Whether or not they employ architects, however, the Regional Board's need for the services of Regional Engineers will not be disputed by anyone who has understanding of the two professions."

To this we take exception.

There is ample room in the hospital service and the war against ill health for both Regional Architects and Regional Engineers provided they possess skill, energy and sincerity of purpose and that there exists between them deference to each other's professional knowledge, mutual respect and close and disinterested collaboration. That such a state can exist has been amply proved in the region in which it is our privilege to serve. It is greatly to be regretted—more especially at this very time when architects and engineers in the hospital service are for the first time beginning to see eye to eye and for the common good of the Service on the many problems that confront them, that, among a number of claims, the justice of which cannot be denied, such irrelevant and contentious statements as those quoted above should have been allowed to creep into the president's address. May we hope that, when next he addresses his colleagues or exercises his considerable influence, the president of the Institution of Engineers-in-Charge will lead his fellow-professionals in an endeavour to solve our common problem in the spirit of the opening lines of this paragraph rather than attempt to exalt his own at the expense of other allied professions, for in such a way engineers show their disinterested wish to serve the hospitals of Great Britain.

P. H. KNIGHTON, Architect,
W. H. EVANS, Engineer,
Newcastle Regional Hospital Board

Newcastle upon Tyne, 2,
October 24th.

PRESENT-DAY LOCOMOTIVE WORKING

SIR,—Referring to the letter of Mr. E. B. Parker in your issue dated 5th October, balancing springs for locomotive reversing shafts have been in use for many years.

The incident mentioned of an occasion when a balance weight fell off the shaft and derailed a locomotive occurred some time about 1887 on the Great Eastern Railway near Norwich.

The engine concerned was one of Massey Bromleys' bogie singles, No. 603, and the balance weight fell under the engine wheels and so derailed the engine and train, causing a number of casualties, some fatal.

The railway company were sued for compensation by relatives of those killed, and for the defence a large-scale model of the engine was made and produced in the courts. The railway company lost the case and were mulcted in heavy damages.

An uncle of mine, now eighty-nine years of age, remembers the accident very well because he assisted in constructing the model, and such was the state of the finances of the company that the works at Stratford were put on short time to help pay the money. This model is still, I believe, in existence.

Subsequently, another similar accident occurred on the G.E.R., but with no casualties, and so it was decided to replace box coiled springs for weights on all reversing shafts, and as an apprentice this was one of the jobs I had to do.

The G.N.R. also used the same type of spring.

GEORGE PERRY

Brighton,
October 12th.

The Thirty-Sixth International Motor Show

No. II—(*Continued from page 523, October 26th*)

AS mentioned already in last week's issue, the majority of British motor manufacturers have refrained from altering their models to any great extent and have concentrated on minor modifications, mainly in the nature of pure refinements, which could be carried out without interfering with the steady flow of production. In these circumstances, we have made no attempt to give a full account of the various exhibits, but preferred to describe in detail the more interesting features of those cars which made their first appearance at this year's Show. We continue our report with a short survey of the basic engineering trends which to-day influence the design and construction of a motor-car.

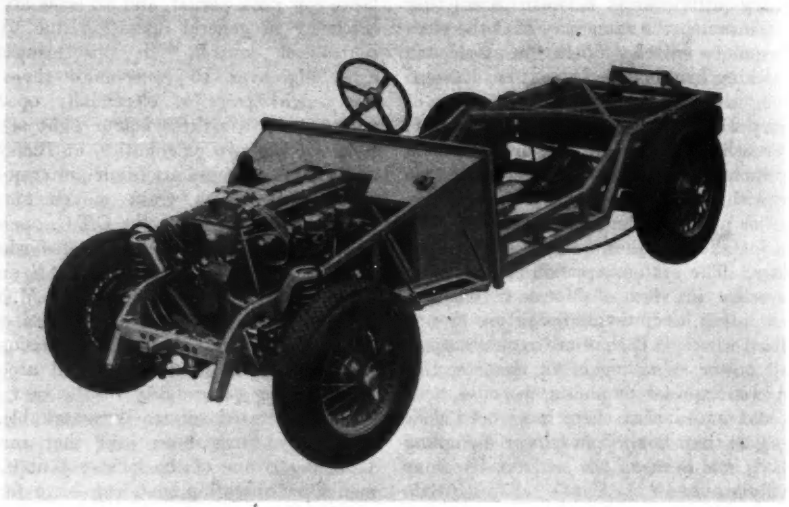


FIG. 8—ASTON MARTIN TUBULAR CHASSIS

CHASSIS

The advantage of the integral body-cum-chassis construction is now generally acknowledged, and it is interesting to note that this system seems to be more popular among British designers than anywhere else. Since Austin has also adopted this principle for the new "Seven" there are none of the big six motor manufacturers left who do not use it either entirely or, at least, for those types of cars which are being made or intended to be made in large numbers. Both the latest Austin and the Vauxhall constructions are interesting examples of good design, combining a maximum of stiffness with a minimum of weight. In either case, careful attention has been paid to overcome the one objection to unit construction in the past, namely, the internal corrosion in light-gauge sections; all bodies are nowadays rust-proofed and the design provides for a sufficient number of holes in the structure to allow the paint to reach otherwise inaccessible surfaces.

Integral construction is only suitable for manufacturers with well-equipped press shops and welding installations. It necessitates considerable investment in expensive jigs and tools, and is mainly used by firms which specialise in making one or two saloon cars in considerable numbers. Manufacturers who cater for a greater variety of body styles, and that applies to many Continental and practically all American firms, still maintain the conventional lay-out of a separate chassis and a body designed for one or another particular purpose.

No major changes are apparent in the construction of the orthodox chassis, the general conception of which has remained static since the introduction of the independent front-wheel suspension. The frames are, with very few exceptions, made up from box-section longitudinal members, braced

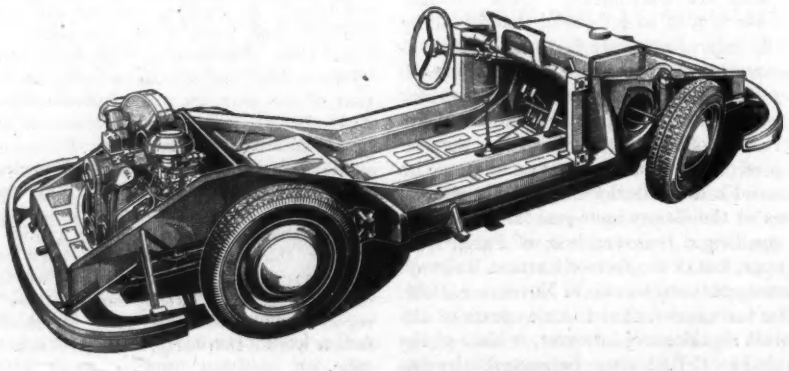


FIG. 9—CHASSIS OF THE 1.3 LITRE PORSCHE CAR

by channel section cruciform members at the centre, and have rigid cross members at the front to carry the brackets for the wheel suspension. Electric welding has almost completely replaced the riveted joints of the past.

Frames with longitudinal members made of steel tubes of wide diameter are being used in the Frazer-Nash; the Jowett also has a system of welded tubes, but of smaller diameter, mainly for stiffening the

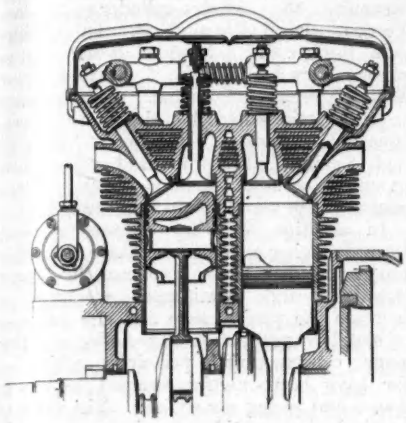


FIG. 10—AIR-COOLED PORSCHE ENGINE

rear of the chassis. A step further in the same direction is to be found in the latest chassis of the Aston Martin (Fig. 8); here the longitudinal members are built up from steel tubes of square section, welded together to form lattice girders with particular resistance to bending, and the required torsional rigidity has been attained by several tubular cross members, by the panels of the very stiff scuttle and by cruciform bracing.

Another chassis which combines exceptional stiffness with light weight is that of the German Porsche (Fig. 9) car. Built by the well-known designer of the "Volkswagen" and actually using a considerable number of components of that car, the

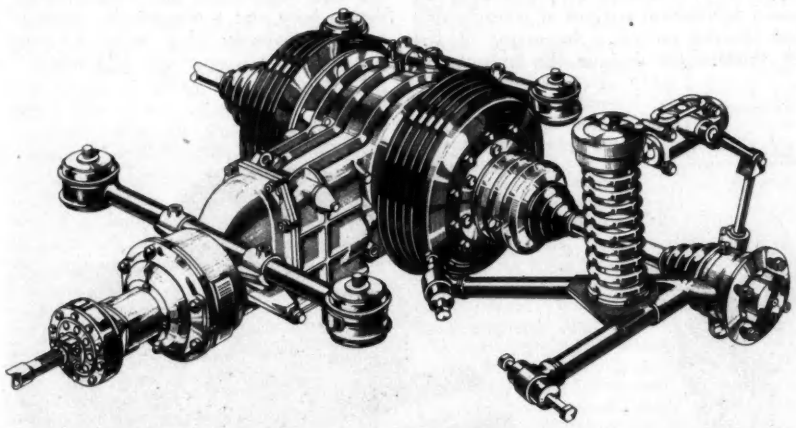


FIG. 11—REAR TRANSMISSION AND SUSPENSION OF LANCIA "AURELIA"

Porsche chassis has very stiff longitudinal members, built up from suitably reinforced pressed steel panels and welded to a flat pressed steel floor with a channel-shaped centre section. Tubular members at the front and at the rear carry the laminated torsion bars for the front and rear suspension, and transverse panels in front of the rear engine and at the scuttle provide a high degree of torsional rigidity.

Though the number of firms making chassis built up from steel tubes or pressed steel panels is still small, it seems likely that more manufacturers might eventually adopt this principle, which, incidentally, is quite suitable for mass production as well as for production on a smaller scale.

The body style has undergone very few alterations since last year. The absence of bonnet sides as the bonnet merges into the front wings, recessed headlamps and built-in bumpers make the car look like one piece rather than a body with various parts attached. The majority of cars at the Show have a good appearance, though some firms which, for one reason or another, stick to the so-called "restrained" or "dignified" style of bodywork have still to find an æsthetically satisfying solution to blending a full-width body into a narrow bonnet with the orthodox distinguishing vertical radiator grille. The interior trim and finish of nearly all the cars displayed, British as well as foreign, with hardly any exception, is in good taste and style, and we are glad to note that the use of 18 carat gold instead of chromium for plating bumpers and radiator grilles has not yet become generally accepted practice.

Instruments in the new models are now better arranged and more readily observed. A good example in this respect is that in the Ford "Consul" and "Zephyr"; speedometer, ammeter, petrol gauge, oil warning light and ignition light are grouped together at the top of the steering column and are clearly visible through the top half of the three-spoke steering wheel, the horn ring of the "Zephyr" having been modified to permit an unrestricted view of the instruments. Instead of the usual cubby holes a full-width, deep parcel shelf is fitted underneath the dash.

WHEEL SUSPENSION

No noticeable advances have been made in the design of independent front-wheel suspensions, the general lay-out of which follows the now almost standard pattern of transverse wishbones of uneven length with some sort of frictionless spring, either a torsion bar or, more frequently, an open coil spring. Telescopic double-acting dampers, which have proved to be more wear-resistant than the rocker-type, two-piston dampers, are the rule and, when housed inside the coil spring between the lower wishbone and the spring bracket attached to the frame, permit a neat and compact lay-out. A good example of a modern front suspension is the Vauxhall design (our issue of Oct. 26th), in which a torsional anti-roll stabiliser is linked to the lower wishbones, a lay-out which is becoming increasingly popular. Referring to a less orthodox suspension mention might be made of the ingenious Ford system, introduced at last year's Motor Show and described in detail in THE ENGINEER, November 24, 1950, page 505, which has proved to be satisfactory; only recently we had the opportunity of convincing ourselves of its performance.

As far as rear axles and rear suspensions are concerned, the design and construction has remained static. In this country, and also in America, a rigid rear axle is employed,

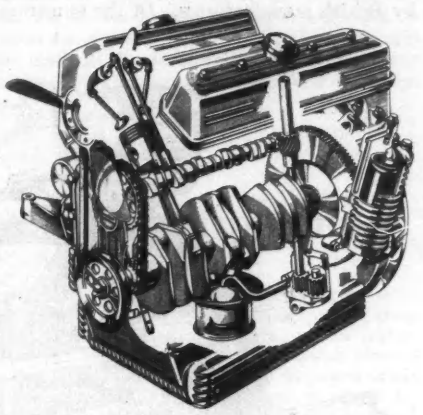


FIG. 12—VALVE GEAR OF LANCIA "AURELIA"

embracing a hypoid bevel gear, mainly in conjunction with semi-elliptic leaf springs. The system is simple, satisfactory and considerably cheaper than the independent suspension of the rear wheels, although not as satisfactory as this design, in fast cars and those of low weight and short wheelbase. Frictionless springs for rear suspensions are used by several British manufacturers of sports cars; the Aston Martin, Healey and Jensen cars employ coil springs, whilst Bristol, Frazer-Nash and Jowett models have torsion bars in connection with a live rear axle. In all these cars the thrust and the brake reaction is taken up by some sort of linkage or radius arms. Independent drive to each rear wheel through separate propeller shafts from a frame-mounted bevel gear casing is used by two British manufacturers, the Allard and Lagonda companies, the former employing the Dion-Bouton axle in conjunction with coil springs, and the latter, radius arms and torsion bars. Independent rear suspension seems to be more popular on Continental cars, and not simply when dictated by such circumstances as a front-wheel drive (Citröen and Panhard) or rear-engine mounting (Renault and Porsche). It is also to be found in the new 2-litre Renault "Frégate" and in the Lancia "Aurelia," which made its first appearance in this country at last year's Show.

Fig. 11 shows the unusual, but very interesting lay-out of the Lancia rear drive assembly and rear suspension. The clutch and gearbox have been removed from the engine and form a single unit with the final bevel gear drive and the differential. The whole assembly is attached in rubber mountings to the body structure, and the torque is transmitted from the final drive to rear wheels by half shafts, each fitted with two universal joints. Each wheel is located by a forked member ahead of the wheel centres, one arm of which is pivoted to a horizontal axis fixed to the gear casing and set at an angle of 60 deg. to the centre line of the car, while the other is linked to a bracket attached to the longitudinal member of the body structure. The two pivots do not line up but are set at a slight angle to each other,

and the deviation from the theoretical pivot axis is taken care of by the deflection of rubber bushes which are continuously stressed by tension. Coil springs are set directly above the swinging arms, and horizontal two-piston type dampers are employed.

Engines

Apart from the power units of the Austin "Seven" and the Daimler "Regency," which have been described in our issue of Oct. 26th, no new engines have been developed by British manufacturers. Of the numerous minor modifications which lately have been carried out, on current engines, we should like to mention the adoption by the Standard Motor Company of a new form of controlled heating of the inlet manifold for the 2-litre engine of the Standard "Vanguard" and the Triumph "Renown." It consists of a jacket around the centre of the manifold through which hot exhaust gases circulate. A thermostatically controlled butterfly valve shuts the circulation off when the engine reaches a preset temperature and diverts the gases straight into the exhaust pipe. A balance weight holds the valve in this position until the temperature of the engine drops below a certain minimum. This device ensures rapid warming up when starting and should help to reduce fuel consumption and cylinder wear.

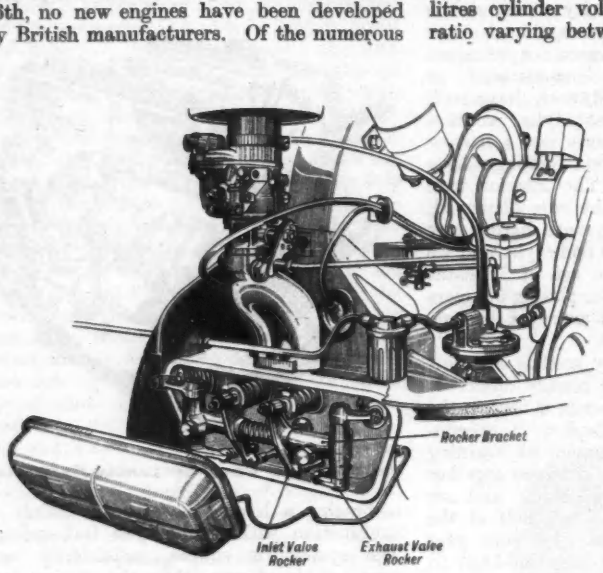


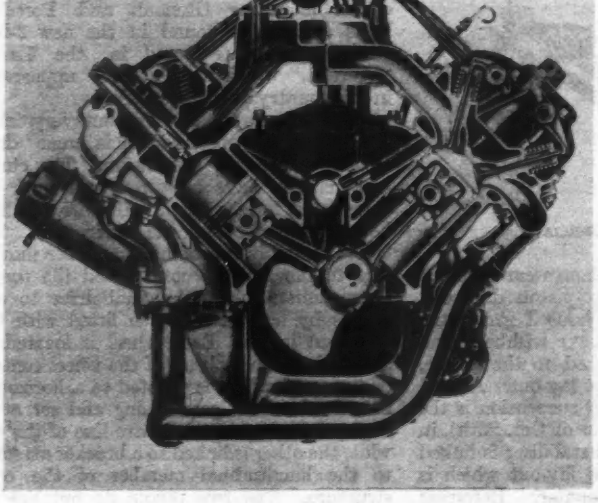
FIG. 13—PORSCHE ROCKER GEAR

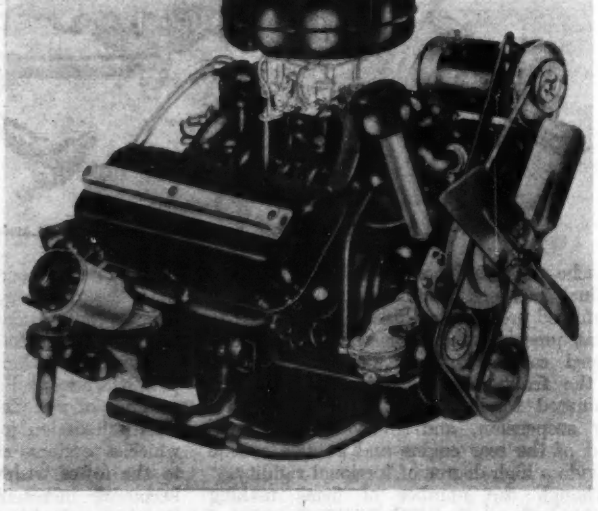
In order to get a general idea of the tendencies which govern the design of British engines to-day, we can assume that the power units for medium-size, mass-produced cars are more or less built after one standard pattern. They are four or six-cylinder engines of something between 1·2 and 2·5 litres cylinder volume, with a compression ratio varying between 6·5 and 7 : 1, and a specific output of about 30 b.h.p. per litre. There are still some side-valve engines in this category, but future development clearly points to a more general adoption of push-rod-operated overhead valves. The more complicated valve gears, such as valves in line, actuated by one overhead camshaft (Wolseley, Morris "Six," Singer); valves set at an angle in a hemispherical combustion chamber, operated either by two overhead camshafts (Jaguar, Lagonda), or by push-rods (Bristol, Frazer-Nash, Riley), are almost entirely confined to high-performance engines. The combination of overhead inlet and side exhaust valve, a lay-out which gives particular smoothness and good economy, is fitted in engines of expensive cars such as Bentley, Rolls-Royce and Rover.

With the exception of the last-mentioned arrangement, which is practically unknown outside this country, the Continental engines, shown at the exhibition, do not differ to any great extent from British designs. There seems, however, to be a definite tendency among foreign designers to concentrate on standard production engines of considerably higher specific output. In many of the latest Continental designs the output per unit of cylinder volume has been raised to at least 35 b.h.p. per litre, mainly by the expedient of increasing the engine speed to 4500 r.p.m. or more. The short-stroke engine, square or even "super-square" (bore-to-stroke ratio >1), allows a high engine speed without increase of the mean piston speed and the accommodation of large valves in the cylinder head. It has therefore become quite popular. Foreign representatives of the short-stroke construction include the 1·2-litre Simca, the new 2-litre Renault, the twelve-cylinder 2·5-litre Ferrari, the 1·4-litre Fiat, the 1·9-litre Alfa Romeo, the 1·1 and 1·3-litre engines of the Porsche, and the 5·4-litre Chrysler V-8 "Firepower" engine. This country is only represented by the two "super-square" engines of the Ford "Consul" and "Zephyr." It is probable, however, that, in spite of certain objections, the short-stroke engine will be viewed more favourably here.

In addition to what appears a trend towards higher engine speed there is another tendency, though not pronounced, among American and Continental designers to increase the performance and the economy of standard production engines by adopting some constructional principles which so far have been mainly confined to use in sports and racing car engines. The value of hemispherical combustion chambers which, apart from other advantages, permit the accommodation of large valves, and the "streamlining" of valve ports has been recognised for many years. There has been reluctance to incorporate this design in engines for production cars, mainly because of the complex and expensive gear required for operating valves, inclined relative to the cylinder axis. In some recently developed engines these difficulties have been overcome in a comparatively simple way without the necessity of employing two camshafts or overhead camshafts.

A good example of such a design is the Porsche 1·1-litre, air-cooled, horizontally opposed, four-cylinder engine of 73·5mm bore and 64mm stroke with a compression ratio of 7 to 1, and output of 44 b.h.p. at 4000 r.p.m. (Another version, the 1·3-litre Porsche engine of the same stroke, but 80mm bore and a compression ratio of 6·5 to 1, develops 40 b.h.p. at 4000 r.p.m., but has a better torque characteristic.) Both





FIGS. 14 AND 15—CHRYSLER "FIREPOWER" V8 ENGINE

engines, in their broad specification, are similar to the 1·13-litre engine of the "Volkswagen," which, with the low compression ratio of 5·8 to 1, develops 25 b.h.p. at 3300 r.p.m. The considerable increase in output has been attained by increasing the engine speed and the compression ratio, and by improving the heat flow and the volumetric efficiency. For this purpose the cast iron cylinders have been replaced by chromium-plated aluminium cylinders, and the light-metal heads (one for each pair of cylinders) have been completely redesigned. Instead of the disc-shaped combustion chamber of the "Volkswagen" engine, the Porsche engine, owing to the offset cavity in the piston crown, has an almost spherical, asymmetrical combustion chamber (Fig. 10). The valve arrangement suits these conditions; it incorporates an inlet valve, parallel to the cylinder axis, and an exhaust valve of slightly smaller diameter inclined to it. The valves are actuated through push-rods and rockers from the camshaft, which is located above the crankshaft, and while the rocker shaft of the inlet valves is parallel to the camshaft axis the two rocker shafts of the exhaust valves are at right angles to it. Fig. 13 shows a view of the rocker gear of one cylinder bank; it also shows the carburettor, feeding one bank of cylinders, and the casing of the centrifugal blower for the cooling air.

Interesting, not only because of the valve gear, but in its whole conception, is the 1·75-litre V-six-cylinder engine of the Lancia "Aurelia." The engine, of 70mm bore and 76mm stroke, develops 55 b.h.p. at 4000 r.p.m. The maximum b.m.e.p. of 110 lb per square inch is not exceptionally high and could probably be bettered by raising the compression ratio, which is 6·85 to 1. Two banks of three cylinders with wet liners, set at an angle of 60 deg., are cast in aluminium integral with the top half of the crankcase. Each bank has a separate aluminium cylinder head with inserts for the valve seats. The combustion chambers are hemispherical, and the valves are arranged fore and aft relative to the cylinder axis and inclined to one another at an angle of 52 deg. The six-throw crankshaft, with the crankpins evenly spaced at an angle of 60 deg., is carried in four main bearings and drives the camshaft by a duplex roller chain which is tensioned by an oil-pressure-loaded sprocket. The valves, as shown in Fig. 12, are operated through hollow aluminium push-rods and by rockers, the shafts of which are arranged at right angles to the camshaft axis. The Lancia engine, though not as completely balanced as the straight six-cylinder or a V-eight arrangement, is compact and easily accommodated under a short bonnet.

A typical example of a modern American eight-cylinder V-engine is the Chrysler "Firepower," a 5·42-litre engine of 96·8mm bore and 92·1mm stroke, with a compression ratio of 7 to 1 and an output of 180 b.h.p. at 4000 r.p.m. This short and compact engine (Figs. 14 and 15) is the power unit of the latest Chrysler and "Plymouth" cars, and of the Allard "J.2" competition two-seater. The two banks of four cylinders are set at an angle of 90 deg. and are cast in one piece with the top half of the cast iron crankcase. Each bank has a cast iron cylinder head with inserts for the exhaust valve seats. The combustion chambers are hemispherical, and the valves, which are inclined at an angle of about 60 deg. to one another, are arranged in line on each side of the cylinder head. They are actuated, as shown in the illustrations from one camshaft, above the crankshaft, through push-rods and rocker arms. Each cylinder bank has two longitudinal rocker shafts, one carrying the rockers for the inlet valves, the other those for the exhaust valves. The Chrysler valve gear is simple and probably cheaper than other systems designed to actuate inclined valves by means of push-rods. It has the advantage of providing sufficient space for large valves, and permits a clean and unrestricted design of the intake and exhaust porting. The Chrysler Motor, Ltd., further claims that valve lifts attainable with the new gear are the highest ever used in an overhead valve engine of comparable size.

The maximum engine speed up to which this gear or, for that matter, any of the previously described valve-actuating systems can be used depends on the inertia of the rocker arms and push-rods, but for all engine speeds, likely to be employed for ordinary production engines in the immediate future, one or the other of these systems should be quite adequate.

To sum up this review on engines, it can be stated that there are no indications yet that design is likely to undergo drastic alterations in the next few years, but experimental work in this direction is going on at all times and in all motor-producing countries, and it is to be expected that further progress will be made in the development of lighter power units of still better performance and economy.

Ultrasonic Tyre-Testing Equipment

An instrument which embodies one of the more important applications of industrial ultrasonics, the non-destructive testing of materials, has recently been put into operation in the works of the Dunlop Rubber Company, Ltd., at Birmingham, England. The instrument, which has been developed jointly by the Dunlop Research Centre and the General Electric Company, Ltd., is designed for the production testing of aircraft and motor vehicle tyres of all kinds. The story of the project goes back to 1943, when, owing to the scarcity of rubber, it became necessary to find a non-destructive method for determining whether the internal structure of aircraft tyres had been damaged by landing stresses and the tyres were therefore unfit for re-treading.

The method developed depends on the fact that any internal discontinuity, e.g., imperfect bonding between rubber and fabric will necessarily lead to the presence of an air film and that this rubber/air boundary will cause almost 100 per cent reflection of ultrasonic waves which reach it. With new tyres a fault of this type is possible, though rare, but with used tyres it is common and may make it inadvisable to renew the treads, notwithstanding the fact that the tyre is superficially sound. The equipment described below is suitable for tyre testing on a production basis and is capable of detecting faults having an area of ⅛in by ⅛in or more.

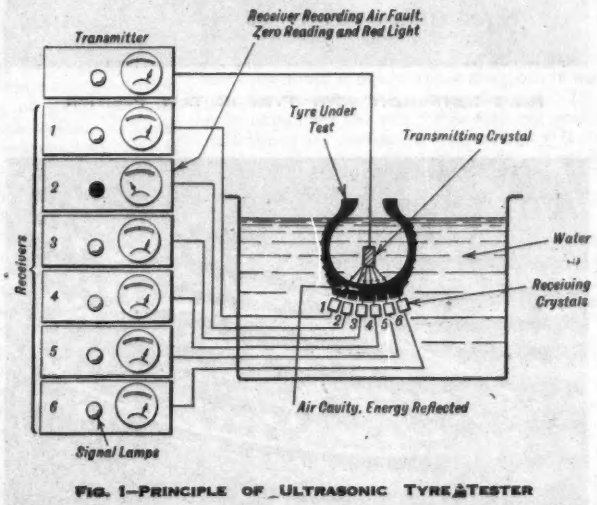


FIG. 1—PRINCIPLE OF ULTRASONIC TYRE TESTER

Referring to Fig. 1, which outlines the principle of the test method, the equipment consists essentially of an ultrasonic transmitter head housing a ⅛in diameter quartz crystal mounted in a brass holder placed 1in from the rubber in the well of the tyre, which is under water. The reason for using a water bath is that water produces a good transmission path between transmitter and receiver, together with reasonable acoustic matching with the rubber, i.e., there is negligible absorption or reflection at the water/rubber boundary. If a dry contact was used it would be practically impossible to exclude air. This would result in nearly 100 per cent reflection of the wave, which would be unable to pass freely into the rubber.

The ultrasonic beam is radiated at an angle of 120 deg. and a single transmitter within the tyre can be used with up to six receiving crystals spaced around the outer wall. Leads are taken from each of the receiving crystals, to separate amplifiers, and the outputs of these are used for visual indication on six meters and for the operation of six alarm circuits consisting of a relay and a red indicator lamp. Each amplifier has independent controls for setting the meter indication and point at which the alarm lamp lights.

The frequency of the ultrasonic generator is 50kc/s and the power output about 1W. Choice of the frequency is determined by practical circumstances because, as frequency increases, the angle of the radiated beam becomes less, until at about 1000kc/s it is almost parallel, with a diameter approximately equal to that of the transmitter crystal. Furthermore, the absorption of ultrasonic energy by rubber increases rapidly with frequency and this sets a practical industrial upper limit of about 500kc/s; accordingly, the instrument is designed to use a frequency of about one-tenth of this figure. This value results in a wide angle of radiation, so that a single transmitter can serve six receiving crystals. It also has the advantage that reasonable signals can be obtained without the use of elaborate high-gain amplifiers.

The instrument (Figs. 2 and 3) consists of a steel cabinet which contains an ultrasonic generator and valve amplifiers, together with pneumatic handling equipment for lowering the tyres into an adjacent tank of water, where they are tested. Projecting from the front of the cabinet is a pneumatically operated extensible arm, which can be given a cycle of operations to enable it to move outwards and to project beyond the tank so that a tyre can be loaded on to it, whereupon the arm lifts the tyre, moves it inwards and lowers it on to two

rollers which are mounted in the tank, above the water. The rollers can be used to revolve the tyre at speeds up to 10 r.p.m. during a test and are driven by an ½ h.p. motor, through reduction gears. The reason for the speed range is that when a tyre is first immersed it is desirable to revolve it quickly for wetting purposes, and then to slow down for an ultrasonic test, and if necessary to drop to "very slow" or "stop" for precise location of a flaw. A rear view of the cabinet with the cover panel removed is given in Fig. 3, which shows, on the left, a group of cam-operated valves and, on the right, the actuating cylinder and piston which moves the arm carrying the tyre.

The technique of using the equipment is that after the tyre has been lowered into the tank it is rotated quickly to wet it and remove air bubbles. If desired, a small amount of non-foaming, wetting agent can be added to the water. The ultrasonic generator is then adjusted to give a meter indication of about 80 per cent of full-scale deflection on each of the receiver indicators. It should be noted that the apparatus does not depend to any extent on an absolute calibration, but purely on the fact that an area of the tyre can be considered as "good," all other parts being tested relative to this sound portion.

Next, the tyre speed of rotation is reduced according to the size of the tyre and the size of the fault which is being sought. A large aeroplane tyre (or any tyre where defective areas greater than 1in by 1in are being sought) can be rotated at 6 r.p.m., but lower speeds have been found to be better for smaller tyres or for smaller areas. Each revolution of the tyre results in about a 90 deg. arc of cross section being scanned by the crystals and means are provided so that the transmitter and receiver crystals can be rocked about an axis by means of an electric motor, to enable the whole tyre to be examined in a few revolutions. After a test has been completed, the water within the well of the tyre is removed by means of a small pump and the pneumatic lifting equipment operates to remove the tyre from the test tank, back on to a trolley or conveyor.

The pneumatic handling equipment is designed to operate from the works compressed air main and is automatically controlled by cam-operated air valves, with means for adjusting the speed of the loading or unloading cycle. The ultrasonic generator is provided in duplicate, together with a spare receiver amplifier and meter panel, so that the electronic equipment of the tester can be serviced without interrupting the production testing sequence.

Small variations in the tyre structure cause small and rapid variations in the meter indications when the equipment is in use, but an operator can soon learn to distinguish between these and true faults such as actual or incipient looseness between layers of fabric.

Typical defects that can be detected by the ultrasonic test equipment are illustrated in Figs. 4 and 5, which show cross sections through two faulty tyres. The cavities in Fig. 4 would cause a 50 per cent drop in signal strength. The flaw in Fig. 5, would give a 100 per cent fall in signal strength.

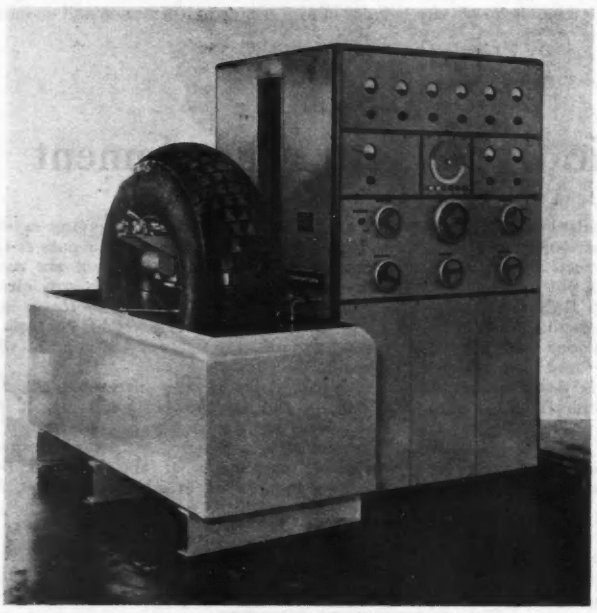


FIG. 2—INSTRUMENT WITH TYRE IN TEST POSITION

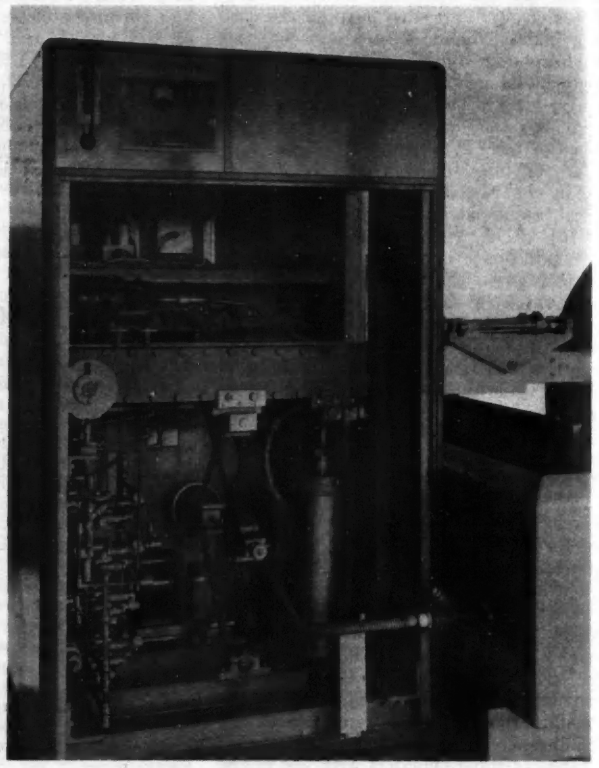
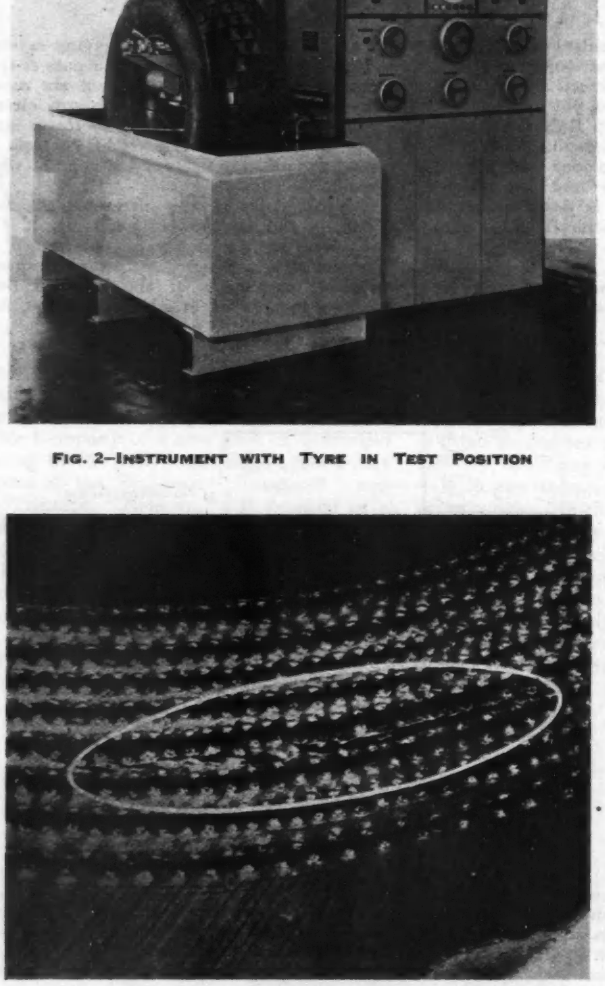
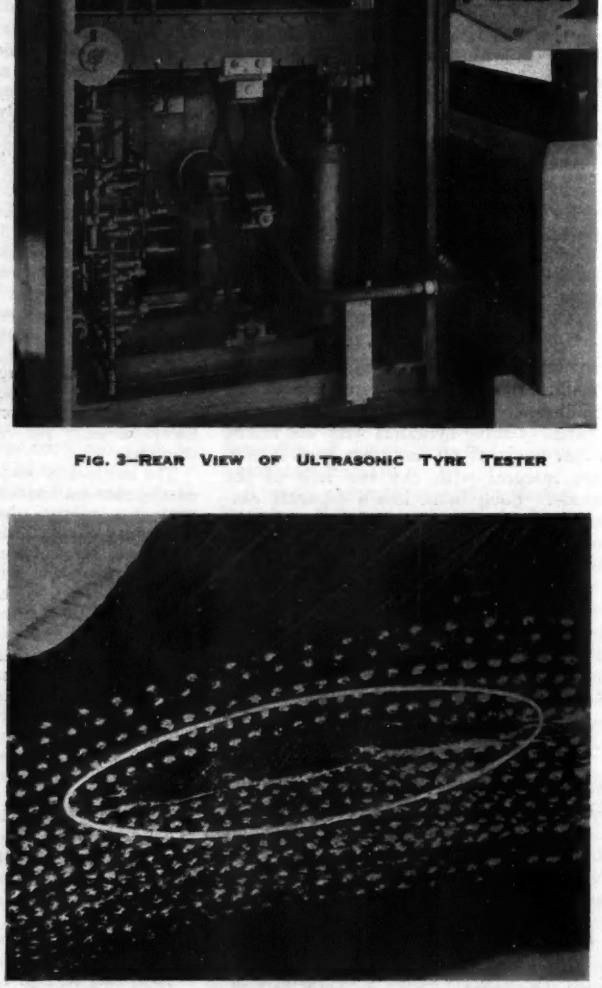


FIG. 3—REAR VIEW OF ULTRASONIC TYRE TESTER





FIGS. 4 AND 5—TYPICAL CAVITIES DETECTED BY ULTRASONIC MEANS

NIGERIAN OIL WELL.—The first deep well to be drilled for oil in Nigeria, West Africa, has been "spudded-in" near Owerri by the Shell-D'Arcy Petroleum Development Company of Nigeria, Ltd., on behalf of the Shell and Anglo-Iranian organisations. Surface seepages have indicated the possibility of oil deposits and an area of 60,000 square miles is being explored at a cost of £1,500,000.

The Institution of Mechanical Engineers

AT a general meeting of the Institution of Mechanical Engineers on Friday, October 26th, the following paper was read :—

PRINCIPLES OF CONTINUOUS GAUGE CONTROL IN SHEET AND STRIP ROLLING

By W. C. F. HESSENBERG, M.A.,* and R. B. SIMS B.Sc., A.M.I.Mech.E.†

SUMMARY

The problem of longitudinal gauge variations in hot and cold-rolled sheet and strip metal is considered. It is suggested that they are caused mainly by elastic distortions of the mill in response to variations in the separating force between the rolls. A unique relationship is shown to exist between the roll force and the thickness of the strip leaving the rolls, and this forms the basis of two new methods of continuous automatic control of gauge. These methods are independent of any direct measurement of the thickness of the sheet or strip during rolling. They employ an electrical roll force measuring element the output of which, after suitable modification, continuously adjusts either the position of the rolls or the tension applied to the strip, so that a substantially constant thickness is maintained in the rolled material. Some preliminary experiments on a 10in by 10in two-high mill have demonstrated that these methods of control are correct in principle.

DISCUSSION

Professor Hugh Ford, D.Sc., Ph.D., Wh.Sc. (City and Guilds Engineering College), said that he would like first to refer to one small matter in the design of the equipment. It was stated that the load meter potential difference was matched against a reference voltage. It would seem, therefore, that the control depended upon the constancy of this reference voltage. He would like the authors to say how far changes of line voltage and frequency varied the reference voltage, and what precautions they had taken to ensure that the limits fixed for this voltage were such that the resulting signal passed through the amplifying chain did not cause a significant change of strip thickness. It was clear from the results quoted that the automatic control was far more effective than hand control, presumably because of more rapid response. Obviously, for very high-speed rolling, where gauge control became so important, rapid response was a necessity. It would be of interest if the authors could give any figures for the rapidity of response of the automatic and manual control, and could say how quickly the automatic linkage could take control when starting up. Presumably, a lap or two around the windreel coiler were necessary before sufficient tension could be applied to give the full range of control of gauge, an important consideration when rolling thin strip, where the ends might be thick anyhow and the speed effect augmented the change of thickness. In that connection, could the authors say, from their experimental results, what was the range of tension required to control gauge to the extent shown in the paper ? Existing cold rolling mills had only a limited coiler power, and he was wondering how far such existing coilers would be capable of modification to suit automatic gauge control.

A far more important application, however, would be in tandem mills, rolling down to thin gauges at high speed and with high interstand tension. It was clear from the paper that the degree of control over the variations of interstand tension was of great importance as far as constancy of gauge was concerned, and therefore several interesting points arose. To what extent did existing controllers for interstand tension operate satisfactorily from the point of view of giving rise to gauge variations ? Tensions applied between stands could be very high and any variations must be shown up in the strip. This led to two questions. First, the power available at the winder in tandem mills was usually somewhat limited, and it would appear that it would be necessary to use the interstand tensions, i.e., to apply the control to the mill motors with high-speed mills. In that respect the inertia forces involved in motor armatures, gear units and so on was considerable, yet rapidity of response to follow gauge variations would be imperative. The accelerations and decelerations involved would be very high, and very large variations of input power would therefore have to be made for control. The authors had probably given consideration to this problem, and it would be interesting to have their comments on how far they had gone in applying the control to such mills.

In that connection, an interesting operating problem arose. Much off-gauge strip was produced during acceleration and deceleration of the mill ; the greater the running speed of the mill, the greater was the change in gauge between threading and running speeds. At present, no method existed for avoiding the proportion of off-gauge material except to cut down the acceleration and deceleration times to a minimum and to use bigger and bigger coils. Such high acceleration rates required the mill and the coiler motors to be far greater than would be needed to provide the running power, on account of the inertia torque which had to be provided. A few calculations would show that, with large coils and high speeds, the gain in production from high acceleration rates was not commensurate with the capital and running costs involved, and a much slower acceleration and deceleration rate would be an advantage if against the small loss of output could be placed the almost complete removal of off-gauge strip by automatic control. It would be interesting to know whether the authors had calculated the optimum operating conditions, either for a typical or for an actual mill, with regard to driving motor sizes and power necessitated by high acceleration rates, the effect of lower acceleration rates on output, and the degree of control of gauge possible during acceleration and deceleration. These factors were obviously interdependent, and it seemed to him that considerable advantages could be obtained by using lower accelerations in large high-speed mills, if that could be associated with automatic control of gauge by tension.

One further practical point seemed to him to be of importance, particularly in single-stand reversing mills. As he had already said, the coiler motors were limited in size and the magnitude of the tension which could be applied was accordingly limited. Most mill operators would like more tension than they had at present, and it was a common experience to find mills working with the highest tension which could be got out of the coiler. If now the strip gauge was to be controlled by tension variation, might not the whole operating technique be modified if the expense of more powerful coilers was to be avoided ? In other words, would the available tension be sufficient in the average mill to allow of complete control of the gauge variations met with on the average strip going to the mill ? Even if it was sufficient would the fact that the average tension must be much lower than the upper limiting tension mean that the operative would not have enough tension at the lower limit to keep the strip straight and under control ? The answers to those questions really depended upon an earlier question, i.e., what was the range of tension required for this method of control ?

Mr. M. F. Dowding, A.M.I.Mech.E., said that from the point of view of the mechanical engineer, and in particular the mechanical engineer engaged in mill design, there were two things which could be learned immediately from the paper. One would help to make mills cheaper, and the other to make them more expensive. Housing post areas had been going up for years and had now reached 1000 square inches per post on mills where 400 or 500 square inches would have been considered adequate a few years ago. It was possible now to think of reversing this trend, provided the mills could be fitted with automatic gauge control.

From the mechanical point of view, the present-day reel design at once became suspect. It was no easy matter to design and build reels which would take the weight of coil used to-day and the tension which was used to-day without the drum collapsing, and to make them so that they did collapse when one had finished rolling the coil. It would mean a major mechanical problem if the tension was increased in the large proportion that he expected, and it would make the mechanical engineers think, but there was no doubt that they would solve it.

Mr. G. R. Wilson (English Electric Co., Ltd.) said that in the single passes quoted in the paper equal gauge was obtained, but presumably at some expense of inequalities in hardness. Would the authors say whether any further passes had been made on strip having such constancy of gauge, and whether in so doing any of the errors had been reintroduced due, for instance, to the hardness inequalities ? The earlier attempts at gauge control, by using the normal flying micrometer on the outgoing side of the mill, had always struck him as fundamentally wrong, in that the error was detected after it had left the mill, and because any control system had a necessary though slight time delay. In the authors' method there seemed to be two fundamental advantages. First, the measurement of error was at an earlier time in the history of a point in the strip, and this would inherently allow of better correction, since the control system, with its inevitable delay, would have longer in which to do its job. Secondly, the averaging of the total roll load at the two screws seemed to give a reading much more representative of the conditions across the width of the strip.

Mr. P. W. B. Wanklyn (Richard Thomas and Baldwins, Ltd.) said that the authors mentioned in the paper that roll eccentricity and thermal expansion could not be covered by the suggested automatic control. It seemed to him that the position was worse than that ; not only could it not be controlled, but it would actually operate in the reverse sense. If the rolls expanded the roll force went up and the exit thickness decreased, but, as the roll force went up, so the screws would come down and the thickness would still further decrease. He wondered whether he was correct in making that comment.

Mr. E. A. Cooke (W. and T. Avery, Ltd.) said it would seem quite correct to make use of the relationship which was shown to exist between the roll force and the thickness of the strip leaving the rolls as the control function ; but it was not clear to him why, in the authors' conception of their first practical method, they chose to adjust two variables, roll force and strip tension, when it would seem adequate to adjust only the former, as was done in the second method which they described.

The authors used the mill rolls both as detecting and as correcting elements. The earliest at which an error could be detected was when it just entered the rolls. Correction, to be effective, must be applied at the latest by the time the error reached the plane containing the axes of the rolls ; response time must therefore be extremely rapid. Taking the 10in diameter roll used by the authors as an example, and a strip speed of only 1000ft per minute, the response time must be of the order of $0{\cdot}5 \times 10^{-3}$ sec, or 1/2000 sec. Furthermore, the full effect of the change was not felt over the full period of time, due to the large horizontal component upon entry. He would suggest, therefore, that the most profitable type of control to develop for this purpose would be based upon the relationship existing between roll force and strip thickness, but which would use an error-detecting device on the ingoing side in a system where the time lag was synchronised with strip speed. He believed that there was one such device already in a fairly advanced state of development.

Mr. J. Hooper read a contribution from Mr. N. H. Polakowski, who was unfortunately unable to be present. Mr. N. H. Polakowski (University College, Swansea) wrote that the

* Head of Mechanical Working Division and Deputy Director, British Iron and Steel Research Association.

† Head of Rolling Section Mechanical Working Division, British Iron and Steel Research Association.

authors had made quite a point of the fact that they took the master control impulse from the load-meter and not from a thickness gauge, but it was difficult to see why this should necessarily be regarded as a virtue of their methods. The only argument put forward against thickness measurement was that the thickness gauge was placed at some distance from the roll gap. This distance might vary from a few inches to a yard or so, and it did not represent a problem in rolling strips which were usually very long. With regard to thickness measurement on hot strip, the non-contacting X-ray gauge and other similar devices had solved this question almost completely, and they were being installed at a rapidly increasing rate in the U.S.A. From the engineer's point of view a direct method was preferable to an indirect one, and it was surely better to measure thickness by thickness than by roll load. The authors' concept of keeping the gauge constant was based on the assumption that whenever the strip thickened the roll load should rise simultaneously. This was not always so. The increase of roll load in proportion to the thickening of the metal between the rolls was an inherent property of what could be called a fully elastic mill, i.e., a mill in which the consecutive elements connecting one roll with the other behaved in accordance with the laws of elasticity, as was the case in the Sheffield mill when equipped with roller bearings. In a talk with one of the authors a few months ago, the writer drew attention to the fact that hydraulically loaded mills, such as were used for foil rolling, could not be controlled by the roll force method. However, mills of this type were rarely used and did not represent a major problem. On the other hand, four-high mills equipped with fluid film bearings were extremely common, and they probably represented the most typical rolling equipment for bulk production of strip. In a paper published a year ago in *Iron and Steel Engineering*, Stoltz and Brinks gave a full account of their tests on the five-stand Weirton mill. They found that an approximate 30 per cent increase of gauge during deceleration from 4000ft to 400ft per minute was accompanied by a fall of roll force of about 9 per cent. To have a double check, they repeated some of the tests on a single-stand, four-high mill with backing rolls carried in oil film bearings, with precisely the same results. The factor responsible for this behaviour was the variation of the operating clearance between the journal and the loaded side of the bearing. The thickness of the oil film and the pressure which it was capable of transmitting were functions of the rotational speed of the necks. With a reduced rolling speed—for example, for threading—the pressure in the oil film fell and the housings contracted accordingly; hence the fall of roll load. On the other hand, with a constant mill speed, the increased thickness of the incoming strip would result in a slight rise of the roll load. With the usual sizes of roll necks, 15in to 30in in diameter, and a diametrical clearance of about 0·001in per inch of diameter of neck, it was doubtful whether any useful response from the load-meter would be obtained to variations in gauge of the order of a few thousandths of an inch. It seemed, therefore, that if the correction of gauge controlled by the load-meter worked properly at constant roll speed it must act in the wrong direction on deceleration and acceleration, and vice versa. At any rate, the problem of differentiation between gauge control during steady and during transient speed conditions was one which required careful consideration.

The authors suggested that the elastic constant of the rolls in their 10in mill was about 4100 tons per inch. He would like to express a doubt whether the figure quoted was the correct one, and whether the alleged "constant" was a constant at all.

Mr. Alec Ellis (Richard Thomas and Baldwins, Ltd.) felt that the problem which the authors had attempted to tackle was that of controlling the gauge while the mill was running at a fixed speed, and a very slow speed in the case of the experimental mill. He had not been aware that it was so difficult to control gauge during steady rolling speed, and all the American articles which he had read had concentrated on control of gauge during slow-speed rolling or thread speed rolling. It was true that their researches had shown a reduction in roll force at thread speed where the material came out over-gauge, not under-gauge, and they had attempted to correct for this by increasing screw pressure at an early part of the mill, probably in stand No. 1, and increasing the tension successively towards stand No. 5. It would seem that the automatic control would do the wrong thing under slow-speed conditions. He wished that the little mill which the authors used could roll at 2000ft or 3000ft or 4000ft per minute, because it seemed to him that the problems at those speeds were far more difficult to overcome than those of a slow-speed mill.

Mr. R. B. Sims, in a preliminary oral reply to the discussion, said that the authors would like to thank the speakers for their kind remarks, and particularly for raising practical difficulties, which they were anxious to have; as research workers, with only limited experience of the difficulties of production, the manifold difficulties of the man who rolled strip for his living and not, as they did, for pleasure, were not always obvious to them.

Many speakers had dealt with the question of the speed effect. To those who were not very familiar with the rolling problem, the speed effect could be summarised by saying that the strip ran thin when the mill was speeded up and thick when the mill was slowed down. He thought that it was permissible to say that in cold rolling the speed effect was the largest single cause of off-gauge. Many speakers had emphasised that if the method of rolling which had been described would take care of the speed effect, rolling problems would be enormously simplified. When the paper was written the authors had done no experiments at all on the speed effect, but since that time some work had been done. The device had successfully controlled a speed effect of 0·004 in.

The range of tension required had been mentioned. It was considerable, and he made no apology for that fact. It was far more considerable than was commonly fitted to mills to-day. He thought that the manufacturer must take the choice of either paying for a bigger motor or having strip off-gauge.

The other method, the variation of the screws, would, he thought, control the speed effect. They had not reached that level of experimentation yet, but the range of tension needed to control the speed effect was, on the strip on which he had worked recently, from 15 tons per square inch down to 5 tons per square inch.

Mr. Polakowski and others had suggested that it would be more fundamental to measure the strip thickness, and in servos in general one should measure the quantity which it was desired to control; but, as he had said, the lags in any practical system based on strip thickness measurement were so great that stability and response became problems which were mutually incompatible. The use of a thickness meter before the rolls had also been suggested. A thickness meter before the rolls would not detect the speed effect. It did, of course, give a form of phase advance of the servo mechanism which would be useful, but the magnitude depended on the speed of the strip, and would be large at slow speeds and very little at high speeds. Servo engineers would be the first to admit that to deal with a practical servo with variable phase advance would not be simple.

Much more would be known about automatic gauge control when they had one on production. At the moment, the roll mill at Sheffield would roll strip to incredibly small tolerances with no one operating the controls at all, but five B.Sc.s standing round it. They would know much more about it when they had five workmen standing round it and it rolled strip day in and day out. They hoped to have such production by the middle of next year, when they installed one of these controls on a four-stand tandem mill in this country, and they might then in another paper be able to give more information about problems to which frankly they did not know the answer at the moment.

Continental Engineering News

(From our Continental Correspondent)

Opening of the Antwerp Oil Harbour

In 1948, the "Société Industrielle Belge des Pétroles" prepared a scheme to set up in Antwerp a large oil refinery covering 375 acres and designed for an annual output of 1 million tons of petroleum products. Because of the magnitude of this installation, the city authorities decided to build an oil harbour, situated south of the Kruisschans Lock.

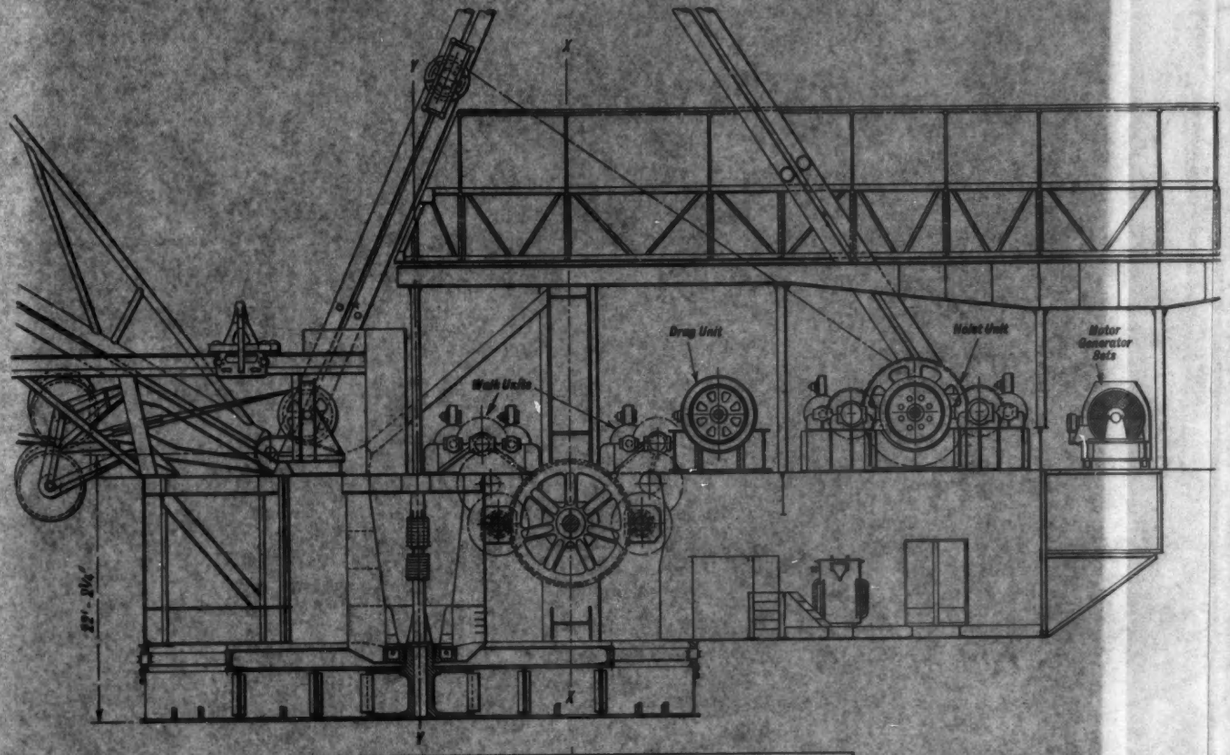
On November 11, 1948, the City Council of Antwerp voted a credit of 100 million Belgian francs (£720,000), followed by a Government grant of 40 million Belgian francs (£285,000). Work started early in 1949 and the new oil harbour was officially opened on September 20th last by Messrs. Behogne and Segers, respectively Ministers of Public Works and of Communications. The port entrance measures 1640ft by 1640ft. It is spanned by two bascule bridges. The entrance is provided with fire-insulating equipment, so that the spread of inflammable products into neighbouring areas is prevented. The harbour basins are designed to accommodate tankers up to 28,000 tons deadweight, having a maximum draught of 33½ft. Amongst the first tankers to use the new harbour was the "British Strength," of the Anglo-Iranian Oil Company. Construction of the oil refinery is advancing satisfactorily.

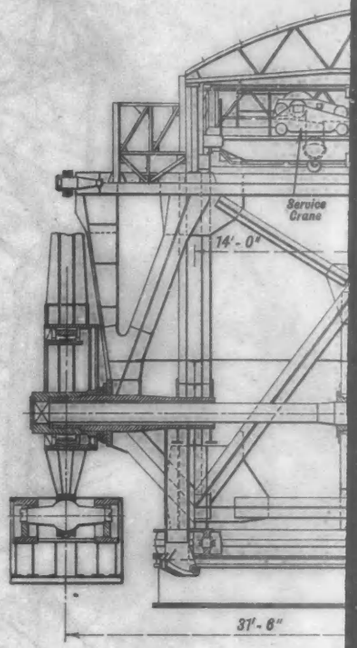
Heavy Engineering Hall at the Milan Fair, Italy

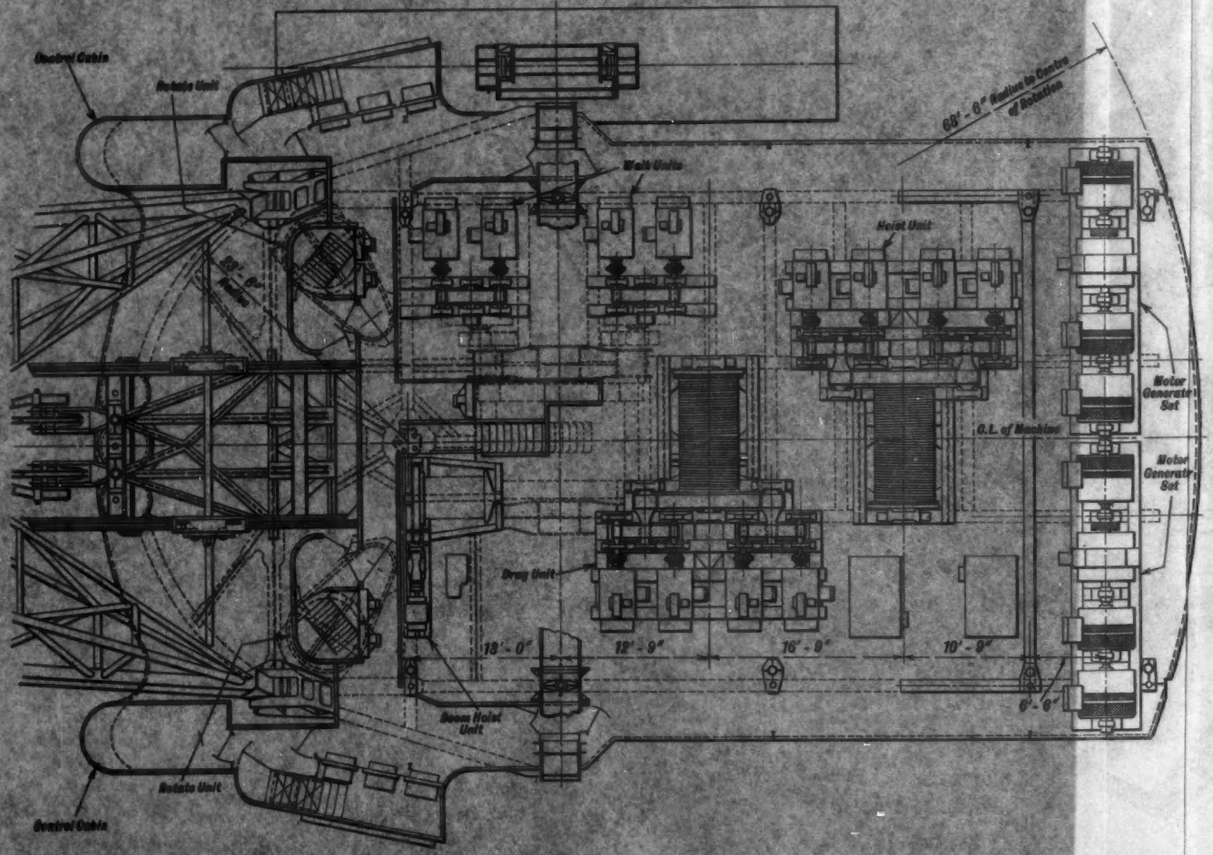
A new hall, covering an area of 120,000 square feet, which is remarkable both for its design and construction, has been erected for the 1951 Industrial Fair at Milan. The hall, destined to house heavy engineering exhibits, is a steel framed structure. The frame consists of lattice truss arches, having a 328ft span. This span exceeds the span of the aircraft hangars recently erected at the New York Airport by some 26ft, and is said to be a record for this kind of structure. The contract was given to the firm S.p.A. Antonio Badoni, and erection of the steelwork was completed in forty-five days; about 800 tons of steel were placed, the weight of steelwork per square foot of covered area amounting to 15 lb per square foot, as compared with 30 lb per square foot required for the construction of the Milan railway station hall, although the span of arches of this hall was less than 245ft.

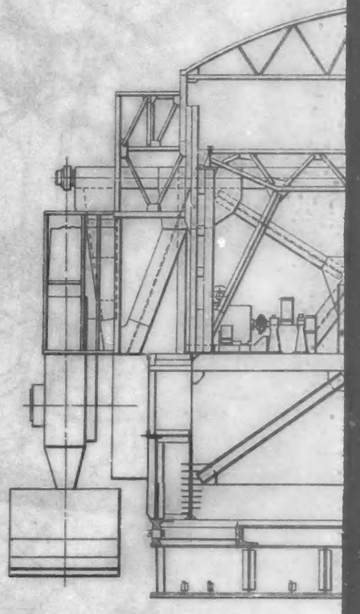
Reconstruction of the Cologne-Mulheim Bridge, Germany

Last month the German Chancellor, Herr Adenauer, opened the new Cologne-Mülheim bridge over the Rhine. The new structure replaces the suspension bridge built in 1929 by the M.A.N. Company, and destroyed during the war. The pre-war bridge had a central span 1033ft long, which was at the time of its erection one of the longest spans of its kind in the world. In 1948, the German authorities concerned arranged a public competition for the design of a new bridge having the same dimensions as its predecessor; forty-one designs were presented to the competition. From them, the authorities selected for execution the project "Hängebrücke 48," submitted by the M.A.N. Company in co-operation with some other building firms. The design was prepared in collaboration with architect Riphahn, civil engineer Menne, and Professors Haerter and Bruno. The new structure is a suspension bridge with a central span 1033ft and two side spans each 315ft long. On the Cologne side, there are two approach spans 174ft and 151ft long. Continuous cables, 3778ft long, are used, consisting of thirty-seven ropes, 2·8in in diameter. The rise of the cables is 109ft. The decking, 93ft wide, accommodates a 56½ft roadway for vehicular and tramcar traffic, two cyclist paths, and two footpaths, each 11½ft wide.


Drag Unit
Hoist Unit
Motor Generator Sets
Walk Units
22'-3½"

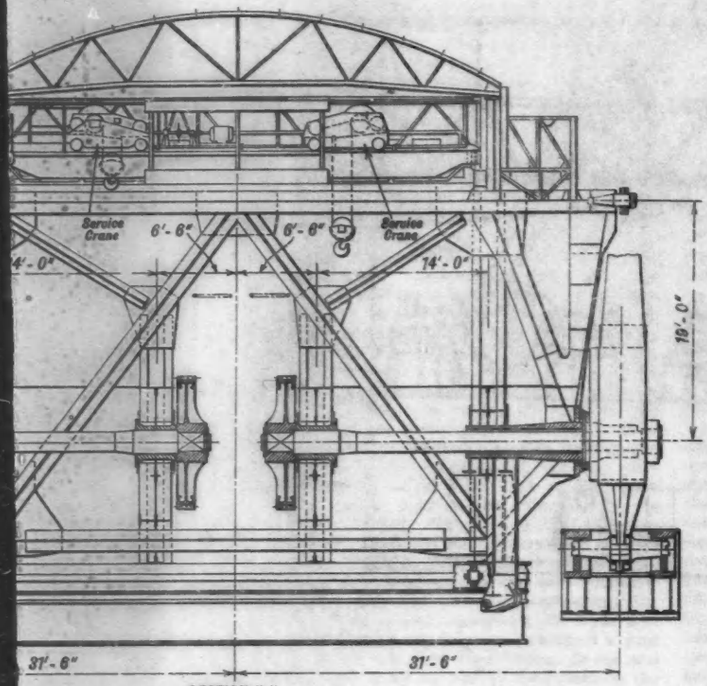

Service Crane
14'-0"
37'-6"


Control Cabin
Rotate Unit
68'-6" Radius to Centre of Rotation
Walk Units
Hoist Unit
Motor Generator Set
C.L. of Machine
Motor Generator Set
Drag Unit
13'-0"
12'-9"
16'-8"
10'-9"
6'-6"
Boom Hoist Unit
Rotate Unit
Control Cabin

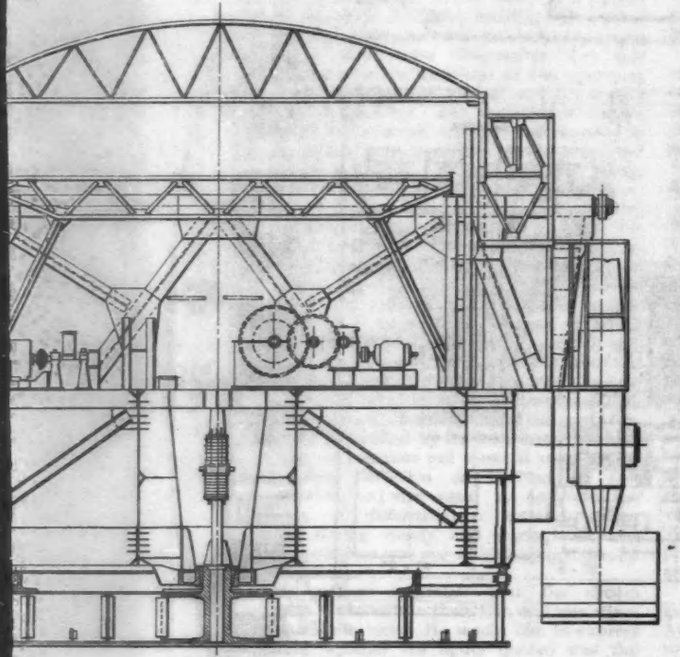


20 CUBIC YARD WALKING DRAGLINE AT CORBY

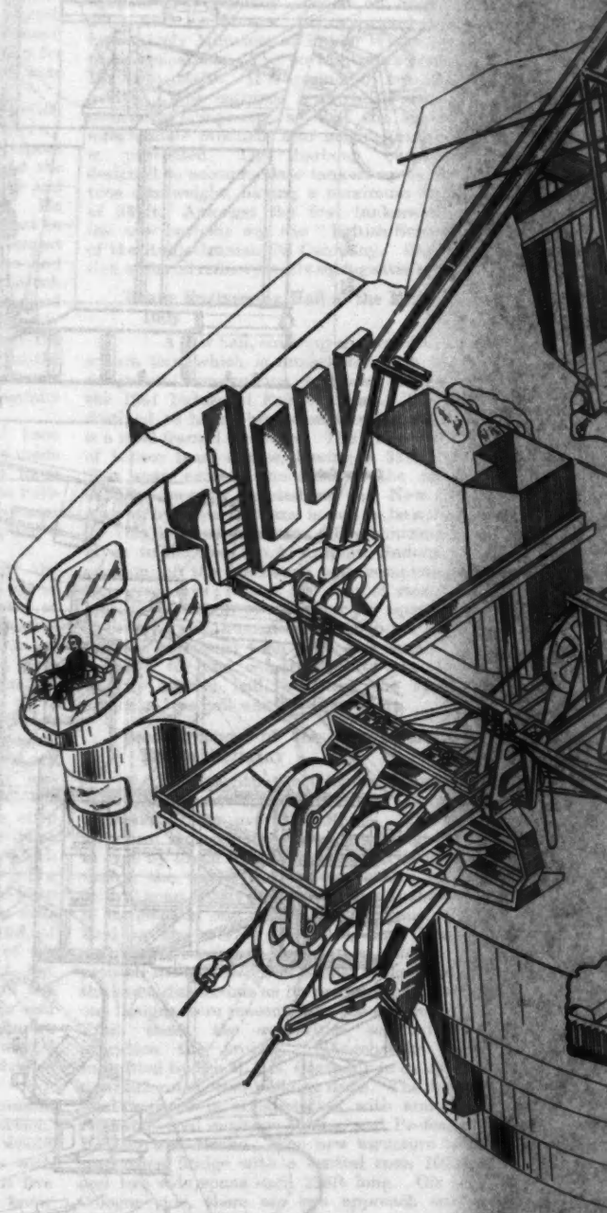
RANSOMES & RAPIER LIMITED, DESIGNERS AND MAKERS

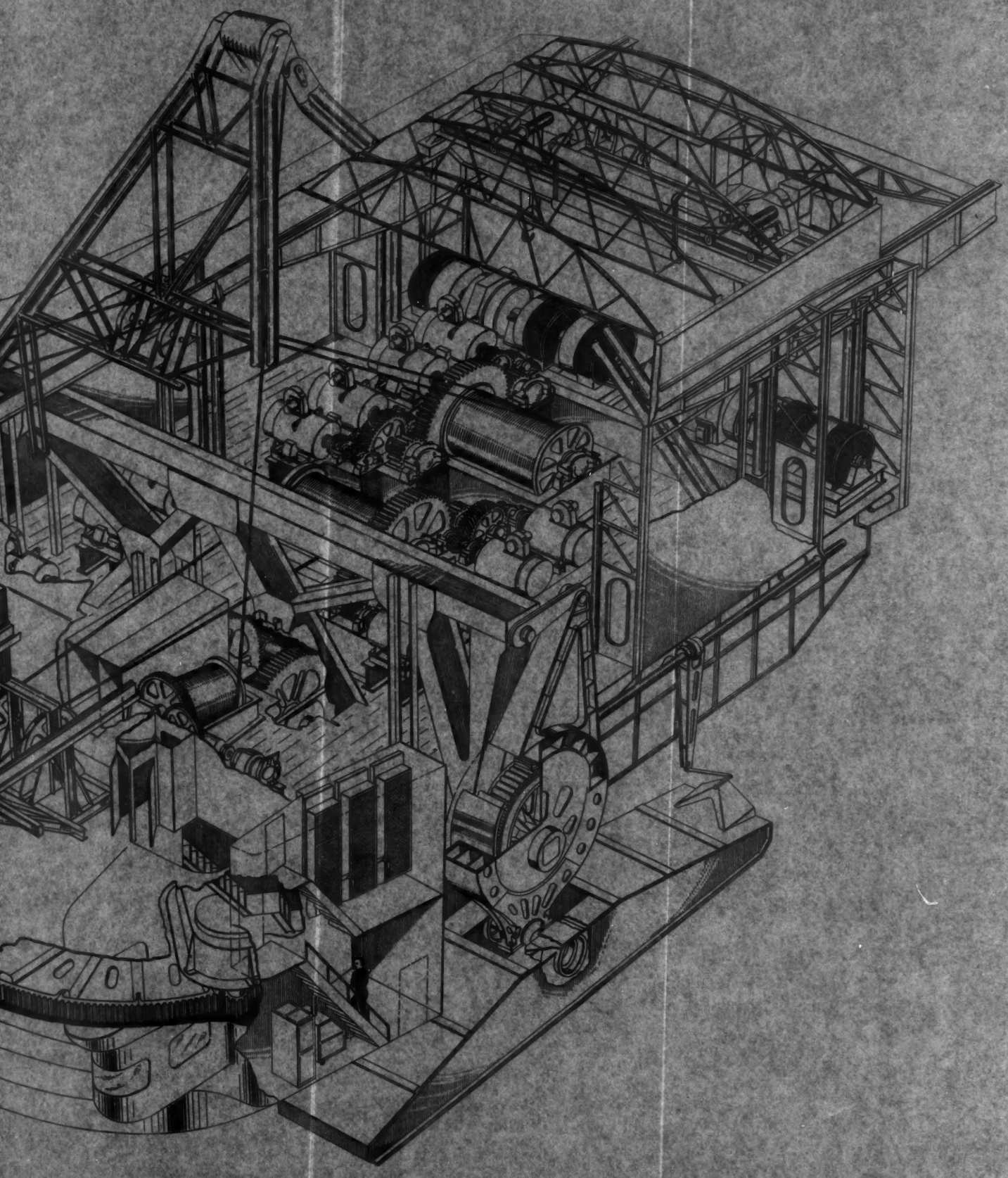


SECTION X.X.
(Looking Forward)



SECTION Y.Y.
(Looking Aft)





Electrical Engineering and Research at Queen Mary College

IN our issue of May 8, 1936 (page 483) we described the newly opened high-voltage laboratory at Queen Mary College, University of London. It will be recalled that the main items of equipment included transformers to give 500kV at 50 c/s, an impulse generator to give 1000kV, a Schering bridge and a high-voltage cathode-ray oscillograph. Since the war the facilities for research work in high-voltage engineering at Queen Mary College have been further enhanced by the installation of some interesting new plant, and it was to see something of the developments that have taken place in the past fourteen years that we paid a visit to the electrical engineering department of the College, at the invitation of Professor W. J. John, who is the head of the department.

Before describing the physical changes that were to be seen in the laboratory installations it is appropriate that we should refer, briefly, to the equally significant changes that have taken place in the syllabus and curricula of the engineering faculty, with particular reference to the electrical department. Similar evolutionary developments have taken place in other schools of the University of London, but the following remarks apply particularly to Queen Mary College. The first important change is that, since the 1948–49 session the degree courses in the faculty of engineering have been taken in three parts, instead of in two parts subsequent to Intermediate, as was done formerly. Entry to the courses is governed by a number of alternative conditions, based on the preferred condition that students must hold the General Certificate of Education with passes at advanced level in pure and applied mathematics, physics and chemistry.

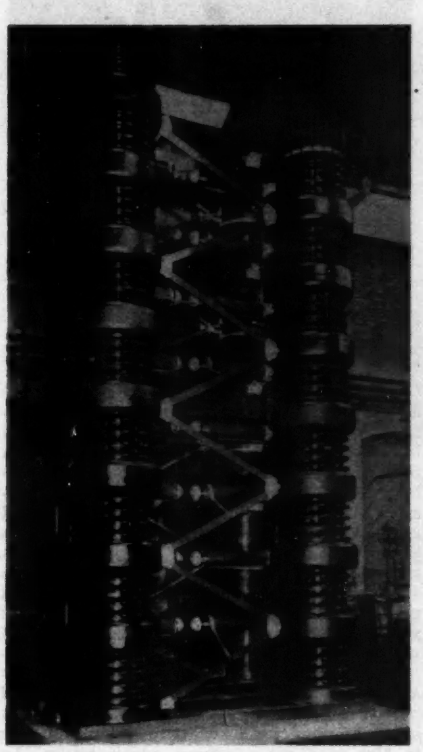
Part I of the engineering course is the same for all students and comprises mathematics and machine drawing, theory and design of machines, strength and elasticity of materials, mechanics of fluids, applied heat and applied electricity.

In the next year, Part II students choose one of four divisions, namely, civil, mechanical, electrical or aeronautical. The subjects taken in the electrical division are mathematics, electrical technology "A" and "B," electrical theory and measurements, theory and design of machines, and strength and elasticity of materials. It will be seen that, in Part II, three of the six subjects are electrical, while two of the remainder are mechanical.

In Part III specialisation is taken a stage further. Electrical engineering students take electrical subjects only, with the option of taking mathematics as an alternative to one of those subjects—the syllabus being arranged to suit the different aptitudes and preferences of students. There is one compulsory subject—electrical engineering materials and measurements—and there is a choice of any three of the following subjects:—(*a*) Electrical theory, (*b*) theory and design of electrical machines, (*c*) electrical power, (*d*) high-voltage technology, (*e*) telecommunications, and (*f*) mathematics. This choice allows students to exercise a preference for the light engineering side (by taking electrical theory and telecommunications), or for the heavy side (electrical machines and electrical power). Similarly, the syllabus caters equally for the student who has the necessary qualities for research work, as well as for the student who is destined for other branches of the electrical industry. High-voltage technology is included because the electrical engineering department has, for a number of years, paid special attention to this subject and it has a well-equipped high-voltage laboratory.

Besides the four subjects, Part III students have to undertake one or more "problems" and this innovation makes an interesting departure from the orthodox examination curriculum. The problems may take various forms; for example, a study of papers on a particular subject, followed by a small amount of experimental work; an extended laboratory test; a study and design without experimental work, or a critical study without experimental work.

In the electrical engineering department the problem usually involves an extended laboratory test. Among the problems recently undertaken are investigations of corona discharge on double conductors; a study of the effect of barriers on the breakdown voltage of spark gaps in air; the construction of a photo-electric amplifier for the study of spark discharges, and the synthetic testing of fuses. There is no doubt that the introduction of the "problems" has been a marked success. The task is, in effect, a minor piece of research work,



IMPULSE GENERATOR

involving the same mental approach and offering the same scope for initiative as a full-scale piece of research. It assists a student in deciding whether research work appeals to him and it helps the staff to determine whether the student should be encouraged to proceed with research.

Research

The main lines of research are the study of (*a*) high-voltage phenomena, (*b*) dielectrics, (*c*) short-circuit phenomena, (*d*) high-voltage particle accelerators.

High Voltage.—The high-voltage laboratory which was opened in 1936, was equipped with transformers to give 500kV at a frequency of 50 c/s, an impulse generator to give 1000kV, a Schering bridge, and a high-voltage cathode-ray oscillograph. Of late years the emphasis has been on impulse work, and the department has designed a new impulse generator for 1500kV; it is intended to increase this to 2000kV. The new impulse generator, which was designed and largely built by the department itself, is shown in the first of the photographs reproduced herewith. The generator operates according to Marx's principle of voltage multiplication. It has nine stages with a capacitance per stage of 0·085μF. The maximum charging voltage is 170kV, so that when fully charged the total energy of the generator is 110kW-secs. Provision is made in the design of the generator for doubling the capacitance per stage and for the addition of three further stages to give a total voltage of 2000kV.

The main items of research which have been done in the high-voltage laboratory are on transmission line insulators under deposit conditions; errors affecting the recording of high impulse voltages; measurement of high d.c. voltage by electron diffraction rings; surface discharges on insulators immersed in gases at high pressure; the breakdown mechanism of electronic devices, and study of interstage phenomena of Marx circuit impulse generators.

More recent work is concerned with lightning arrester performance; the breakdown mechanism of long sparks; a study of transients occurring in a voltage-multiplying Marx circuit, and the recording of very high impulse voltages.

Dielectrics.—Research work on dielectrics began in 1946 and has developed rapidly. The rapid progress is due in no small measure to the encouragement and assistance received from the staff of W. T. Henley's Telegraph Works Company, Ltd. A measure of the work accomplished is given by the number of higher degree theses presented, including one on the mechanism of dipole orientation in pure liquids; another on the dielectric loss in solution of polar substances in non-polar solvents, and a third on the dielectric breakdown of some simple organic substances.

Subsequent work includes a study of the dielectric properties of simple substances over a large temperature range (−120 deg. Cent. to +80 deg. Cent.) and for frequencies up to 3000 Mc/s; the dielectric strength of liquids, and the conductivity of liquids subjected to high electric fields.

Short-Circuit Phenomena.—The section of the electrical engineering department concerned with short-circuit phenomena also owes its inception to the electrical industry. The equipment of the short-circuit laboratory was presented by the English Electric Company, Ltd., through its chairman, Sir George Nelson, who is a Governor of Queen Mary College. The equipment includes a large three-phase alternator, a six-element Duddell oscillograph, an air-blast circuit breaker and various auxiliary equipment. A recent addition to the equipment is a transient recorder purchased by means of a research grant from London University. The main research work done with this equipment is concerned with interruption phenomena of fuse wires in vacuum, the rupturing process in single and double-element powder-filled fuses, and interruption phenomena of fuses at moderate overloads. The transient recorder has been used to record, in an interesting manner, transient voltage phenomena accompanying fuse operation. An account of this method appears elsewhere in this issue (page 553).

Research on short circuit phenomena is particularly interesting because it allows University research to enter the field of heavy electrical engineering, instead of being mainly confined to work in light electrical engineering. The short circuit plant can be used by students who intend to find their ultimate professional work in the realm of electrical power.

Short Circuit Plant.—As shown in two of the illustrations overleaf, the short circuit plant comprises a salient-pole alternator and associated exciter set and driving motor, an air-blast circuit breaker, a transformer and a spring-loaded contactor.

The alternator of 1·3MVA normal capacity has a three-phase stator winding capable of generating 6kV between lines and of producing, in a line-to-line short circuit, transient currents of the order of 3kA. The twenty-pole salient-pole rotor is driven by a 30 h.p. continuously rated induction motor through a multiple belt drive, and is excited by a d.c. generator of 10kW capacity. The exciting generator is itself separately excited by an auxiliary shunt generator, the two being mounted on the same

shaft and coupled directly to a further induction motor.

Protection is provided for the alternator by a three-phase air-blast circuit breaker, which can be made to open the circuit at any time up to four seconds after the short has been applied.

The breaking capacity is 150MVA at a maximum voltage of 11kV. The control circuits are so interlocked that the alternator cannot be excited until the air pressure operating the breaker is sufficient to ensure current rupture. A 300kVA continuously rated, 6·6kV/400V, three-phase transformer can be used to transform the alternator output voltage to a lower value before it is applied to the busbars in the test cell. In addition, to facilitate work at 33kV, there is a 550kVA three-phase, 6·6/35·1kV transformer.

The short circuit is made by a spring-loaded contactor capable of switching currents of several thousands of amperes. All operations are controlled from a separate room. The control circuits are made in their correct sequence by a camshaft carrying twenty cams, each cam operating a switch. The time of rotation of the shaft is two, four or eight seconds, which represents the maximum testing period. A six-element Duddell oscillograph and three high-writing-speed, sealed-off, cathode-ray tubes are available for recording the circuit quantities.

Particle Accelerators and Nuclear Power.—The most recent addition to the activities of the department are the subjects of particle accelerators and the basis of the engineering of nuclear power. Part of this work is supported by an outside body—the Atomic Energy Research Establishment. The field is a natural development of the high-voltage work in which the electrical engineering department has specialised for a number of years.

High-voltage particle accelerators used by physicists in their nuclear studies include the cyclotron, the betatron, the synchrotron, the linear accelerator, and the Van de Graaff generator. The department has constructed a Van de Graaff generator to give 1000kV, and a team of research men is investigating the factors which influence its performance. Another research group is investigating the dielectric behaviour of gases such as freon and sulphur-hexafluoride since these gases may be used to provide the atmosphere in which the generator will operate. The investigations are made with gas at pressures up to 70 atmospheres.

The Van de Graaff generator is a small experimental unit as illustrated herewith. It is constructed in a 5ft high-pressure vessel designed to withstand 750 lb per square inch. A high voltage is generated by spraying charge on to an insulating cotton or glass belt which carries the charge to a high-voltage terminal made from a 16in diameter aluminium hemispherical shell. The spraying is accomplished by raising the potential of a row of steel needles to about 40kV with respect to an earthed plate placed behind the belt. The needles form corona and the charges are swept away by the belt. With a 6in wide belt running at 4000ft per minute (over 4in diameter pulleys) as much as 300μA can be carried if the pressure is raised to 100 lb per square inch. The field produced by this charged belt is sufficient to cause a further row of needles in the high-voltage terminal to produce corona and so discharge the belt to the terminal.

The terminal (containing one of the pulleys) is supported by an insulating column which is broken up into twenty sections by brass equipotential plates 15in diameter, each supported by three insulating legs. The potential of these plates is determined by a set of corona needles between adjacent plates. By correctly

ALTERNATOR FOR SHORT-CIRCUIT TESTING

adjusting these needles a uniform field distribution is obtained across the 1in diameter perspex insulating legs. The total height of the column is 15in, which, in compressed nitrogen and also in compressed nitrogen and freon, has withstood more than 1 million volts. The compressed gas allows an increase to more than ten times the voltage obtained in air. The gap between the high-voltage terminal and the pressure vessel is 4½in and the gradient at the terminal can exceed 300kV per inch. The pressure vessel has six armour-plate glass observation windows and weighs a ton.

The high voltage generated is not readily accessible, but can be used to accelerate charged particles. Provision has been made for mounting a 6in diameter evacuated accelerating tube in the supporting column which leaves the pressure vessel through a flange in the base plate. To facilitate shielding from the radiation produced when such energetic particles are stopped, the vessel is mounted over a pit 6ft deep.

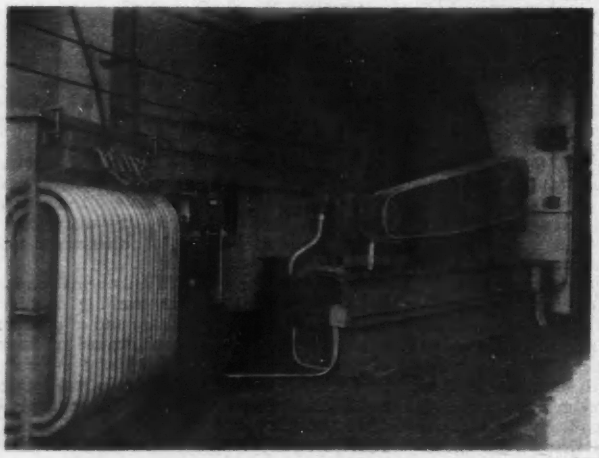
The Van der Graaff generator, together with a low-output betatron and an impulse X-ray generator, will be installed in the new Particle Laboratory. This building is due for completion early in 1952, and will provide accommodation for laboratory work using radio-active isotopes, counters and radiation moniters, as well as housing the accelerating machines. Besides the research programmes based upon these facilities, the laboratory is also to be used for undergraduate course experiments intended to emphasise the important part played by the modern theory of matter in electrical engineering. The radio-active materials section will also provide the practical work to accompany courses of lectures on the principles underlying the engineering of nuclear energy. An electron microscope has also been ordered for this laboratory; it will provide both an example of high-voltage particle engineering and a valuable tool for surface investigation. It is proposed that this facility and the radio-active isotope equipment should be available for use by other Faculties of the College; co-operation with the medical and biological fields, for instance, being an important aspect of this part of electrical engineering.

This brief account of the research activities of the electrical engineering department shows that, while the work is concentrated along a few main channels, there is sufficient variety to give the research student a view covering a fairly wide field. Contact and exchange of information between the groups is encouraged. Thus there is a weekly research seminar at which the lecture is given by one of the research men. He will give perhaps five or six lectures on his specialised subject and his place will then be taken by another man working with another group, each lecture being followed by a discussion.

Equipment for the Artificial Illumination of Plants

INTERESTING results have been obtained from an investigation of the effect of artificial light in speeding the growth of plants, carried out by Mr. W. J. C. Lawrence, of the John Innes Horticultural Institution. These investigations suggest that the practice of artificial illumination has a sound economic basis and that the cost of the installation may in some cases be recovered in a very short time.

For use in such installations the General Electric Company, Ltd., of Magnet House, Kingsway, W.C.2, has designed a suitable illuminating unit which has an inexpensive form of construction and at the same time has the optimum light distribution and is soundly made and safe to use. The light source used consists of an "Osram" mercury vapour lamp arranged for horizontal burning and is of a kind which has been widely used for many years for



SHORT CIRCUIT TEST PLANT

VAN DE GRAAFF GENERATOR

street lighting. This lamp has been found to be the most suitable commercial light source available for plant irradiation.

At present it seems that the most economical use of this method of irradiating plants is in connection with seedlings, because of the large number which can be packed within the illuminated area. The best time to illuminate the seedlings has yet to be determined, but good results have been obtained by pricking them out immediately after germinating and then illuminating them for the next twenty nights for about ten hours a night. The immediate effect of the extra light is to improve the health and vigour of the seedlings and to accelerate their rate of growth; the ultimate effect is to bring about earlier maturity and increased yield of crop.

With a typical ten-lamp installation a total of 1400 tomato seedlings can be illuminated at a time, and for a treatment of twenty nights and for three successive batches of seedlings a total of 4200 can be treated, which is enough for more than a quarter of an acre. The cost of treatment is detailed below, and it has been shown by tests carried out at the John Innes Institution that tomato plants treated in this manner have flowered two weeks or more ahead of non-illuminated plants and, over the season, are generally more than a truss ahead. The following results were obtained in the seasons of 1947 and 1948, on the variety "Potentate," using John Innes No. 1 compost and 3½in pots.

Results of Artificial Illumination of Tomato Seedlings

	Yield in pounds weight per acre		Increased yield by illumination
	Illuminated in seedling stage	Not illuminated in seedling stage	
1947			
Early fruit	24,744	15,876	56%
Total crop..	98,888	96,336	3%
1948			
Early fruit	35,736	16,536	116%
Total crop..	99,660	85,176	17%

These results must, of course, be used with caution; but, taken in conjunction with the costs mentioned below, they show that the capital costs of an installation can be recovered in quite a short time, where tomatoes are concerned, though preliminary trials have indicated that increased yields can also be obtained with cucumbers.

Costs

	£	s.	d.
Plant irradiation unit, type IE/42234, complete with lamp and all starting equipment (for a.c. mains)	15	10	5
Additional lamps	3	3	0

The life of the lamp, used in the manner described, would average four or five years, and the life of the other equipment would be considerably longer if it received reasonable treatment.

The total cost of, say, a ten-lamp installation, assuming that its total life was only ten years and that during this period a dozen spare lamps would be needed, may be estimated as follows with electricity at 1d. per unit:—

	£	s.	d.
Capital cost of a ten-lamp installation ...	155	4	2
Spare lamps in ten years, say	37	16	0
Power costs for ten years	100	0	0
	£293	0	2

The cost per annum would therefore be approximately £30, for which sum sufficient plants to cover a quarter of an acre could be treated. Taking the extra yield on this area to be only 50 per cent and for the early fruit only, about 2000 lb of extra fruit would be obtained per annum, which would clearly make the installation a sound economic proposition. No allowance has been made, in the foregoing analysis, for installation costs. Therefore the cost of the scheme would be increased by an amount covering the cost of installing the plant, but, where electric power is at present in or near the propagating house, the above figures should not be altered substantially.

A Canadian Supersonic Wind Tunnel

THE working section of a wind tunnel for supersonic flight research for the National Research Council has recently been completed at the Lachine plant of Dominion Bridge Company, Ltd. It is believed to be the most advanced yet constructed in Canada.

The working section of the tunnel is 10in square, and the equipment works on the vacuum principle, using a 35ft diameter vacuum sphere.

Air enters the intake throat at the right-hand end of the tunnel as shown in our illustration (Fig. 1) and is drawn through the nozzle box. Nine nozzle boxes were provided, designed to be easily interchangeable, each having a different venturi shape. Thus, the air speed through the tunnel may have nine separate values, depending on which box is in use.

Box No. 1 is rated to give an air speed of Mach Number 1·4. Boxes 2 to 6 are designed to give a progressive range of air speeds up to Mach Number 3·47. The venturi shapes for the remaining boxes will be built by the National Research Council, and it is estimated that with them air speed equivalent to Mach Number of 6·8 miles per hour at sea level (0 deg. Cent.) will be reached.

The left-hand end of the nozzle box projects into the balance box, where the model is mounted, and where the apparatus for measuring the wind effects on the model is housed.

Both the nozzle boxes and the balance box have optical glass windows, 1½in thick, through which shock waves, boundary layers and other flow phenomena can be observed and photographed by means of a Schlieren apparatus.

When the nozzle box is removed, the balance box is capable of being moved forward to allow easy access for mounting the model and adjusting balance apparatus, as shown in another illustration (Fig. 2).

The air leaving the balance box flows through the "adjustable throat" section. Here the roof and floor of the tunnel consist of flexible aluminium plates, capable of being flexed by a system of screw jacks to give varying tunnel heights, ranging from 12·5in to 6·25in. The purpose of this device is to provide means of pressure adjustment inside the balance box (i.e., in the space around the high-speed jet) and to increase the efficiency of pressure recovery. Connected to the adjustable throat is a transition piece which smoothly transforms the tunnel cross section from a rectangle to a circle. A 15in diameter globe valve (Fig. 3), built by Dominion Engineering Works, Ltd., is bolted to the transition piece from which a conical diffuser leads to the vacuum sphere.

The requirements were for valves which would withstand 85 lb per square inch pressure and 15 lb per square inch vacuum, would have

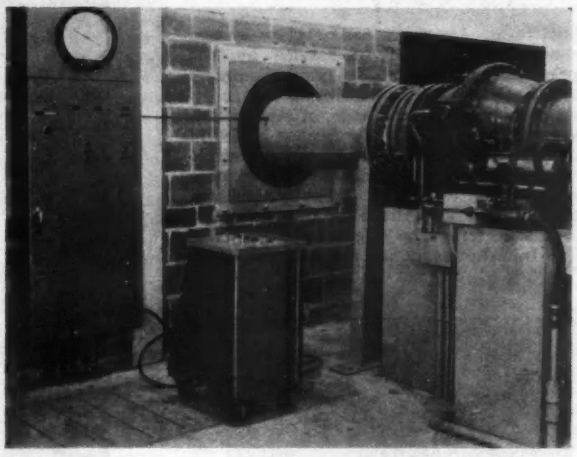


FIG. 3—A 15IN DIAMETER GLOBE VALVE

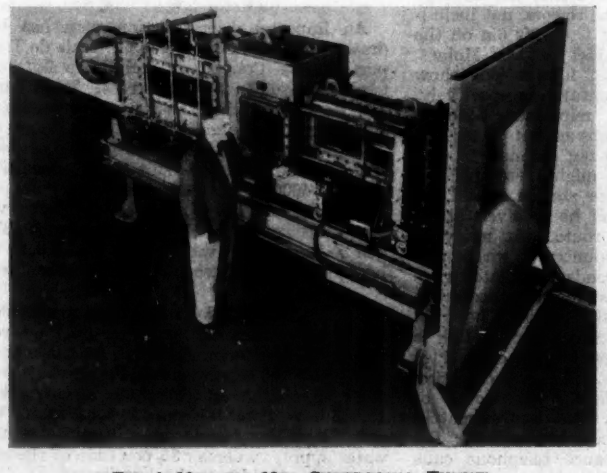


FIG. 1—10IN BY 10IN SUPERSONIC TUNNEL

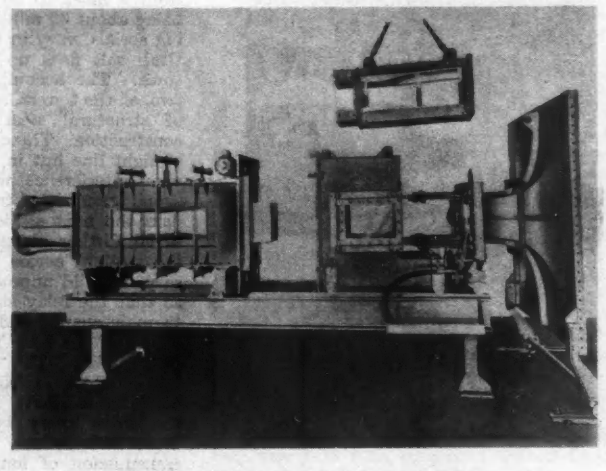


FIG. 2—TUNNEL ARRANGED FOR LOADING

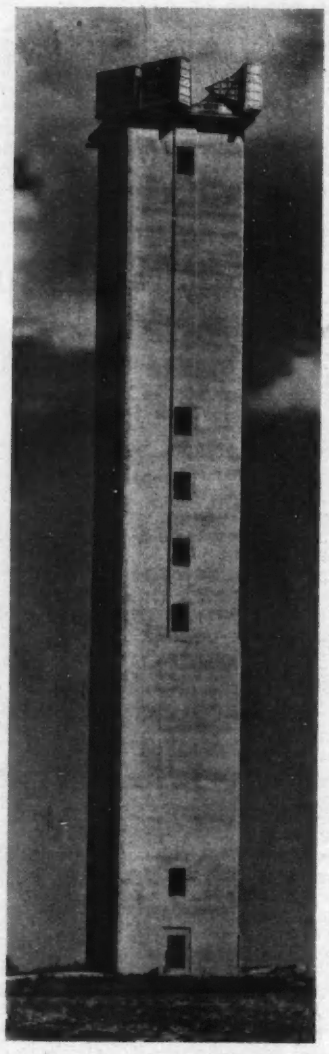
leakproof seals, minimum head losses and an opening and closing speed of only one second. The valves were based on a design originated in Europe for impulse turbine operation, and they were built by Dominion Engineering Works, Ltd.

Accurate workmanship, and the development of special techniques and skills were required to turn out this scientific equipment successfully. The Research Council's original design was modified to suit Dominion Bridge Company shop practices and machines, and all detail drawings were made by Dominion Bridge Company at Lachine.

It is of interest that the company has previously supplied a number of much larger wind tunnels to the National Research Council for tests of bigger models at lower speeds.

Completion of the Trans-American Micro-Wave Relay System

THE trans-American radio-relay system has now been placed in service by the American Telephone and Telegraph Company and was used initially to facilitate the coast-to-coast television broadcasts of the recent Japanese Peace Treaty Conference, held in San Francisco. The operation of this micro-wave link has proved successful and, in contrast, definition and detail it has been shown that the image loses little in the course of transmission from the West Coast to New York. Initial construction work on the trans-continental system started late in 1947. Starting at New York the route of the system is directed to Pittsburgh and on to Chicago. From that city it is carried westward to Omaha, through Denver and over the Rocky Mountains to Salt Lake City and, finally, across the Sierra Nevada range to San Francisco. Similar to radio-relay systems previously built by the Bell System, the transcontinental facility operates in the 4000 Mc/s range, with a corresponding wavelength of only about 3in. There are 107 stations along the route, spaced from 9 miles to 50 miles apart, the average being about 30 miles. The towers, not including aerials, vary in height from 2ft 6in on the Utah salt flats up to 415ft at Des Moines, Iowa. The accompanying illustrations show two of the towers, representative, respectively, of structural steel and reinforced concrete construction. These stations are not placed in a straight line but in a zig-zag manner, to prevent interference which might result if the signal transmitted from one station should by-pass the next station and be received at an aerial further along the route. At many of the stations across the country it was necessary to build approach roads to isolated sites so that the relay stations would be accessible to maintenance and repair teams. The total length of the New York-San Francisco link is 2992 miles. The highest point crossed is Mount Rose in Nevada, with an elevation of 10,075ft above sea level. The cost of the entire relay system was approximately 40,000,000 dollars. It can be used for the transmission of long-distance telephone calls in addition to television programmes.



REINFORCED CONCRETE TOWER

STRUCTURAL STEEL TOWER

French Engineering News

(From our French Correspondent)

A new port is to be built at Avaradrova, in Madagascar. It will cover 30,000 square metres at a cost of 320 million francs. The work is expected to take about thirty-six months. The piles and piers will be constructed in prestressed concrete. This will be the first time such a method of construction has been used in Madagascar.

* * *

A first 46,000 h.p. turbo-alternator set has come into service at Ahrzerouftis, in Algeria. This is part of a big programme of hydro-electric construction in the Kerrata gorge. A pipe-line and a pressure tunnel some 9km long have been completed and it is hoped that a second 46,000 h.p. turbo-alternator set will come into service very shortly. The barrage and reservoir at Iril-Emda, which will hold 160 million cubic metres, will be ready in 1953.

* * *

The important increase in electricity consumption in Morocco has led to the establishment of a new hydro-electric plan. A new water conduit system will be built in the region at Casablanca. Water will be drawn from the Oum-er-Rbia River and brought to Casablanca. A new 30,000kVA transformer is to be installed at Casablanca and another of 15,000kVA at Rabat-Salé. The new water system includes the cutting of conduits over a length of 80km.

* * *

In its latest report the Electricité de France traces the development of French production since 1938. Hydraulic production jumped from 10,500kWh to 16,250kWh and thermal production from 10,300kWh to 16,953kWh. In 1949 thermal production stood at 18,950kWh. The decline in the latter was balanced by an increase in hydraulic production; the E.D.F. did not have to call upon the thermal plants in 1950 to the same extent as in 1949.

Consumption in 1950 was 58 per cent greater than in 1938 and 8 per cent greater than in 1949. The report also outlined international exchange of energy. France imported 92 million kWh from Germany and exported 78 million kWh. From Switzerland France imported 354 million kWh and exported 86 million to her. Finally, France imported 29 million kWh from Italy and exported 127 million kWh.

In 1950 ten new hydraulic plants came into service. The new plants included Couseque (two 32MW sets with 220 million kWh capacity), La Vanelle (three 10MW sets with 147 million kWh capacity), and Aussois (one 30MW set with 120 million kWh capacity). The other sets varied from 3 million kWh to 90 million kWh. New thermal plants included Comines II (50MW), Lourches II (40MW), and Yainville II (50MW).

The size of the network was also increased. The 225kV lines were increased from 5232km to 5809km. The 150kV lines were lengthened from 7943km to 8717km, and 110/120kV lines were reduced from 760km to 720km.

* * *

An important construction plan has been drawn up by the Compagnie Générale de Transport for the Congo. It includes a flotilla of twelve 100-ton to 200-ton barges. These barges will be used during the low-water season for supplying the Bangui region. The barges will be drawn by diesel driven craft, which are being specially adapted to suit local conditions. About 4000 tons of provisions will be delivered monthly. It is hoped that before very long a fleet of tugs will have been built. They will be known as "water mules," and each will be equipped with two 100 h.p. diesel motors.

* * *

The Government is being asked to consider a major programme to lay water on for several thousand rural communities. At the moment there are 37,000 communes in France with under 5000 population and of these no more than 10,503 have water laid on. It is estimated that over 21 million people are still without mains water supply, whereas 85 per cent of the communes are provided with electricity.

Industrial and Labour Notes

Changes in Wage Rates

The latest figures published by the Ministry of Labour concerning wage rates show that changes reported as coming into operation during September resulted in an aggregate increase of about £350,000 in the weekly full-time wages of 1,238,000 workpeople. Among those receiving increases were employees in the road haulage industry and in the iron and steel industry. In the iron and steel industry small increases became payable under sliding-scale arrangements based on the index of retail prices, and in the road haulage industry the statutory minimum remuneration for adult workers fixed under the Wages Councils Acts, was increased by seven shillings a week.

The Ministry says that of the total increase of £350,000 becoming effective during September, about £126,000 resulted from arrangements made by Joint Industrial Councils or other joint standing bodies established by voluntary agreement; about £120,000 resulted from orders made under the Wages Councils Acts; about £84,000 resulted from direct negotiations between employers and workpeople or their representatives, and the remainder was the result of the operation of sliding scales based on the index of retail prices. From the beginning of this year up to the end of September it is estimated that 9,230,500 workpeople received wage increases aggregating £3,983,900 a week. There were no decreases in wage rates reported during the period and the index of rates of wages (June, 1947=100), for all workers, rose from 115 in January to 121 in September. In the corresponding nine months of last year there was an aggregate increase of £603,000 in the weekly full-time wages of 3,278,500 workpeople.

Trade Disputes

The number of stoppages of work in September through industrial disputes was greater than in August, and in the 173 stoppages which were in progress 109,000 working days were lost by the 33,300 people who were directly and indirectly involved. The stoppages which occurred in September included eighty-one in the coal-mining industry and eleven in the transport industries.

The Ministry of Labour has reported that 155 stoppages of work through disputes ended in September. Of that number forty-five lasted not more than one day; forty-four lasted two days; nineteen lasted three days; twenty-nine lasted from four to six days and eighteen lasted more than six days. In the first nine completed months of this year there were 1318 stoppages of work through disputes, which were reported to the Ministry. They involved about 307,000 workpeople and caused an aggregate loss of 1,444,000 working days. In the comparable period of 1950 the number of stoppages reported was 1049, involving 245,300 workpeople and resulting in a loss of 1,045,000 working days.

Steel Production and Scrap

A plea for "a keen personal interest" in the problem of scrap iron and steel collection was made by Mr. George Wood in the course of his chairman's address at the annual meeting of Thos. W. Ward, Ltd., on Friday last. It was, he said, impossible to exaggerate the importance of the matter in relation to the national economy. Mr. Wood pointed out that the furnace capacity of this country could produce over 16,000,000 tons of steel ingots a year if sufficient scrap was passed to the consuming steel works.

It was not an overstatement, Mr. Wood continued, to say that there were many hundreds of thousands of tons of valuable scrap lying about all over the country in the form of derelict plant, obsolete equipment, waste material and the miscellany of items under the benches and at the back of store-rooms in every kind of industry. What was needed, he suggested, was a new approach to the problem on the part of every individual throughout industry. There should be a constant feeling of urgency, an "ever-present scrap consciousness," even to the extent of it being regarded as an offence to neglect starting any scrap, for which the individual was responsible, on its way to the melting works. Only by the most intensive personal effort, Mr. Wood emphasised, could the hidden scrap resources of this country be uncovered.

Prices of Petroleum Products

The Ministry of Fuel and Power announced at the end of last week that, as from October 29th, the maximum prices for the main petroleum products would be increased by a halfpenny a gallon. The increase is in accordance with approved arrangements for adjusting the maximum prices of petroleum products following changes in tanker freight rates.

The new maximum prices per gallon in the inner zones—that is near the main importing centres—are now as follows: motor spirit (bulk), 3s. 3½d. and ex-pump, 3s. 7d.; diesel oil for road vehicles, 3s. 1¾d.; gas oil, 1s. 2¼d.; fuel oil, 11¼d.; heavy fuel oil, 11d.; aviation spirit (100 octane), 3s. 10½d. The Ministry of Fuel points out that the oil distributing companies are, of course, free to sell below the maximum prices. It is also explained that in the "outer zones," that is further from the main importing centres, deliveries cost another farthing a gallon and in the "general zones," or furthest from the main importing centres, another halfpenny.

Exports of Office Machinery

The Office Appliance and Business Equipment Trades Association has announced that in the first nine months of this year office machinery exports reached a value of £600,000 in advance of the total achieved for the whole of 1950. The most outstanding improvement was in accounting machinery exports, which were valued at £2,117,974 in the first nine months of this year, compared with £866,162 in the corresponding period of 1950. Exports of typewriters, which in the first nine months of last year were valued at £1,000,000, increased in the comparable period of this year to over £1,550,000.

The Association adds that output figures for the first four months of this year show that the production of accounting and similar machines was running at an average value of £1,076,000, compared with £979,000 a month during 1950. During the same period typewriter output in this country averaged 13,500 machines a month, compared with 10,900 a month during 1950.

Industrial Injuries in the U.S.A.

The latest issue of the *Ministry of Labour Gazette* includes a summary of some statistics published by the U.S. Bureau of Labour Statistics concerning industrial injuries in the U.S.A. during 1950. The figures relate to "disabling work injuries," which are defined to include temporary as well as permanent incapacity for work if the incapacity lasts for at least one working day after the day of injury.

The Bureau has estimated that the number of disabling work injuries last year was 1,952,000, or 82,000 more than in 1949. Last year's total, however, was the second lowest since 1940. The Bureau takes the view that last year's increase in the number of injuries can be attributed to greater employment and activity in the construction and manufacturing industries, resulting in more hours of exposure to industrial hazards and a rise in the injury rate due to the increased tempo of work. Of the total number of people injured in all industries, 15,500 died as a result of their injuries, and 84,900 sustained permanent disability. The permanently disabled included 1600 who were completely incapacitated for any further gainful occupation. The remainder—approximately 95 per cent of the total—suffered temporary disablement from which they recovered without any permanent ill effects.

From its statistics the Bureau has estimated that, in consequence of work injuries in 1950, the loss of working time amounted to 40,000,000 man-days, or the equivalent of a year's full-time employment for about 134,000 workers. It adds the comment that if allowance is made for the future effects of the deaths and permanent disablements, the total economic loss would be about 212,000,000 man-days or the equivalent of a year's full-time employment for 706,000 workers.

Index of Industrial Production

The index number of industrial production (1946=100), which is prepared by the Central Statistical Office of the Treasury, has been estimated provisionally as 127 for all industries in August, compared with 140 for July. Figures for the corresponding months of last year were 123 for August and 134 for July. Both months, of course, are affected every year by annual holidays. Taking the manufacturing industries only, the index number for August this year has been estimated at 132, compared with 128 in August, 1950. The Treasury says that, on the basis of information so far received, the index for all industries for September this year is expected to be 146 or 147.

Institute of Industrial Supervisors

The Institute of Industrial Supervisors has recently inaugurated a London South-East section, the first meeting being held on October 17th at the Woolwich Polytechnic. At this opening meeting the Principal of the Polytechnic, Dr. J. S. Tait, was in the chair.

Mr. V. A. Patterson, managing director of J. and E. Hall, Ltd., has been elected president of the section, and in addressing the meeting emphasised that the foremen of to-day needed to be well informed about the continual changes taking place in industry and about all matters affecting the control of their departments. Mr. Patterson said that increasing demands were being made upon industry and the fulfilment of those demands depended largely upon the efficiency of industrial supervision. Determination to make the personal contribution to industrial efficiency as effective as possible was most desirable. Foremen, Mr. Patterson urged, could make their individual contributions in their own companies and their national contribution through the activities of the Institute.

Coal Production

Coal output from the deep mines increased last week to 4,286,500 tons. From opencast workings 248,000 tons were produced, so that the total output for the week amounted to 4,534,500 tons, compared with 4,497,600 tons in the preceding week, and 4,377,600 tons in the corresponding week of 1950. In the first forty-three completed weeks of this year the total coal output was 182,672,100 tons, compared with 177,981,200 tons in the corresponding period of last year.

Total coal consumption in this country, however, has this year been considerably in advance of last year. The latest figures published by the Ministry of Fuel and Power show that in the first forty-two weeks of this year inland coal consumption amounted to 165,481,000 tons, compared with 159,116,000 tons in the corresponding period of 1950. On October 20th distributed stocks amounted to 16,707,000 tons, or just over 1,000,000 tons more than on October 21, 1950. Although, at the time of going to press, stock figures for the end of October are not available, it seems likely that stocks may be about 17,000,000 tons.

The colliery manpower decline has not been arrested, the number of wage-earners on the books in the week ended October 20th being 694,200, of whom 285,900 were face workers. In the same week output per manshift at the face was 3·18 tons, compared with 3·16 tons in the corresponding week last year.

Notes and Memoranda

Rail and Road

STANDARD BUILDINGS FOR BRITISH RAILWAYS.—The Railway Executive says that, with the object of producing buildings of good appearance on mass-production lines, standard designs are being prepared for British Railways for various small structures used for railway purposes. Designs have already been produced for signal-boxes, lengthmen's huts, and first-aid rooms.

DEMONSTRATION OF MECHANISATION ON THE RAILWAY TRACK.—British Railways staged a demonstration at Marylebone Goods Depot on Wednesday and Thursday last of the up-to-date mechanised equipment used in the maintenance of British Railways' 52,000 miles of permanent way. On both days morning demonstrations were given to professional and technical bodies, schools and colleges and representatives of British and overseas railways, and the demonstrations were open to the public in the afternoons. About forty different machines were shown varying from a knapsack weed sprayer to a track-relaying machine consisting of three vehicles, complete with power plant.

Air and Water

MARINE GAS TURBINE.—The work of replacing one of the four diesel-electric generators on board the Anglo-Saxon Petroleum Company's oil tanker "Auris" by a gas turbine, built by the British Thomson-Houston Co., Ltd., has been completed at the yard of R. and W. Hawthorn, Leslie and Co., Ltd. The vessel has completed sea trials and without any further adjustments sailed for Tampico.

NAUTICAL INSTRUMENT TRADE ASSOCIATION.—For the third year in succession, Mr. C. G. White, director and general sales manager of Kelvin and Hughes (Marine), Ltd., has been re-elected president of the British Nautical Instrument Trade Association. Mr. J. M. McIntyre, of Heath and Co., has been re-elected vice-president. At the annual meeting of the Association, on October 17th, a fixed national scale of fees for the services of professional compass adjusters was discussed and approved by a large majority. This was considered to be a substantial achievement by the Association, as the principle of a general scale of fees had long been desired. It is felt that its adoption will undoubtedly encourage a higher standard of efficiency.

Miscellanea

NATIONAL PACKAGING EXHIBITION.—It is officially announced by the Institute of Packaging that the third National Packaging Exhibition is to be held at Olympia, London, during the ten days January 20-January 30, 1953.

CARBON BLACK PLANT.—The main contractors of the carbon black plant of Philblack Ltd., Bristol, which was described on pages 537, 538 and 539 of our issue of October 26th, were Head Wrightson Processes, Ltd., which firm was responsible for the engineering of the project.

ALUMINIUM FOUNDRY.—The Northern Aluminium Company, Ltd., has issued a brochure entitled "Northern Aluminium Company's Foundry and Forge." It gives a brief account of the rearrangement and modernisation of the plant and describes the equipment and processes carried out in both foundry and forge. The brochure is well illustrated and includes photographs of the plant and products and views of individual operations.

VACUUM RESEARCH JOURNAL.—We have received the second quarterly issue of the journal *Vacuum*, which was first published in January, 1951, by W. Edwards and Co. (London), Ltd., Lower Sydenham. This publication aims to review developments in vacuum research and engineering. Amongst the original contributions to this issue is a paper dealing with multi-beam interferometry and the influence of vacuum technique, and another paper contains investigations into the ultimate pressures of diffusion pumps designed to purify their working fluids.

MONOPOLIES AND RESTRICTIVE PRACTICES COMMISSION.—The Board of Trade states that it has made a new reference to the Monopolies and Restrictive Practices Commission. The matter to be investigated is the supply of imported timber (hardwood, softwood and plywood). The reference requires the Commission to make a report to the Board of Trade both about the facts of the matter and about the bearing of the facts on the public interest. Any person or organisation wishing to offer evidence on the subject of this reference should write to the secretary of the Monopolies and Restrictive Practices Commission, 3, Cornwall Terrace, London, N.W.1.

DUST PROBLEMS AND THE VENTILATING ENGINEER.—The National College for Heating, Ventilating, Refrigeration and Fan Engineering is arranging a course of extra-mural lectures on "Dust Problems and the Ventilating Engineer." The course consists of ten lectures, which will be delivered on Tuesday evenings, beginning January 15, 1952, at the Royal Sanitary Institute, 90, Buckingham Palace Road, London, S.W.1. Tickets for the lectures can be obtained, free of charge, from the Clerk to the Governors, Borough Polytechnic, Borough Road, London, S.E.1.

INSTITUTION AWARDS—The Institution of Engineers and Shipbuilders in Scotland, at its general meeting on October 9th, made the following awards for papers read before the Institution during session 1950–51:—The W. W. Marriner Premium to Mr. N. V. Pestereff, for his paper "Alternating Current Supplies for Auxiliary Plant on Board Ship"; Institution Premium to Mr. G. Laing, for his paper "Theory and Practice of Thermal Insulation," and to Dr. J. F. Shannon, for his paper "Research, Design and Development Problems in Gas Turbines."

FAULTS IN ARC WELDS.—The British Welding Research Association has published an illustrated wall chart, approximately 3ft by 2ft, with thirty-seven half-tone illustrations indicating common faults which can occur in the metal arc welding of steel. The chart is printed in two colours and is mounted on a very strong backing board, making it suitable for display on the walls of welding shops, offices, &c. Copies of the chart can be obtained from the Publications Department, British Welding Research Association, 29, Park Crescent, London, W.1, price 7s. 6d. each, post free.

THE KELVIN MEDAL.—The chairman and members of the Kelvin Medal Award Committee announce that the Kelvin Medal for 1950 has been awarded to Dr. Theodore Von Karman, F.R.S., of the California Institute of Technology. The medal will be presented to Dr. Von Karman on Tuesday next, November 6th, at 4 p.m., at the Institution of Civil Engineers, Great George Street, London, S.W.1, by Viscount Runciman of Doxford. Dr. W. H. Glanville, president of the Institution of Civil Engineers, will take the chair at the ceremony, to which members of engineering institutions are cordially invited.

INSTITUTION OF ELECTRICAL ENGINEERS' BENEVOLENT FUND.—The annual report of the Court of Governors of the Incorporated Benevolent Fund of the Institution of Electrical Engineers shows that the income from all sources amounted to £17,928 for the year ended June 30, 1951, compared with £19,568 for the previous year. Grants totalling £7777 were made to 115 beneficiaries. To mark the official opening of the "Chesters" residential estate, a simple service of dedication was held in the grounds of the estate on May 18th. Tenants selected by the Court of Governors to occupy the houses and flats took up residence in August and September last year.

OBITUARY.—We have learned with regret of the following deaths:—Mr. Herbert Coope, M.I.E.E., manager of the Cardiff office of Metropolitan-Vickers Electrical Company, Ltd., on October 20th; Mr. T. Caven Irving, A.M.I.E.E., until recently representative in Spain and Portugal of Metropolitan-Vickers Electrical Export Company, Ltd., on October 3rd; Mr. P. E. Banting, formerly manager of the Manchester district office of the British Thomson-Houston Company, Ltd., on October 18th, aged seventy-two; Mr. E. W. Walker, director and secretary of Gibbons (Dudley), Ltd., on October 9th, aged sixty; Mr. Charles Percy Newman, chairman of Newman, Hender and Co., Ltd., on October 16th, aged seventy-six.

CONTROL OF WELD CRACKING.—In the August 1951 issue of *Welding Research*, the journal of the British Welding Research Association, there is a report on "Control of Cracking in Metal Arc Welding of High-Tensile Structural Steels." This mentions the advantages of using low-alloy steel, such as weight saving and economy in transport and erection. The problem of hard zone cracking in the welding of the higher tensile steels was undertaken by the Association and welds from a typical structural unit were examined, the cooling rate being related to the extent of cracking. Critical cooling rates were found which, when exceeded, resulted in hard zone cracking. In the paper the results are used to show how to avoid cracking by making welds of minimum fillet size without preheat, and mention is made of the controlled thermal severity test, which assesses the weldability of a steel and the suitability of an electrode or simulates conditions in a structural joint.

IMPORT LICENSING CONTROL.—The Board of Trade says that as there have been numerous changes in import licensing arrangements since the last consolidated list was published (in September, 1950), amended lists are now available showing the goods exempt from import licensing when shipped from particular groups of countries. The lists, which cover all goods on open general licence, are known as "Notice to Importers No. 458." Copies can be had on application to the Import Licensing Branch, Romney House, Tufton Street, London, S.W.1. An addressed envelope, suitable for a bulky foolscap document, should be enclosed.

HIGHER NATIONAL CERTIFICATES IN CHEMICAL ENGINEERING.—The Ministry of Education has announced the introduction of a higher national certificate in chemical engineering. The scheme, which will become operative for the educational year 1951–52, has been arranged by the Ministry in conjunction with the Institution of Chemical Engineers, and the arrangements and conditions for the award of higher certificates in chemical engineering are described in Rules 122, published by H.M. Stationery Office. Notes on the arrangement of courses for this higher certificate are given in a brochure published by the Institution of Chemical Engineers, copies of which may be obtained on application to the Secretary, 56, Victoria Street, Westminster, S.W.1.

Personal and Business

MR. ARTHUR PARKINSON has been appointed a director of Crompton Parkinson, Ltd.

CAPTAIN R. P. MINCHIN has been appointed general manager of Harry Ferguson Research, Ltd., Coventry.

MR. E. J. BATCHELOR has been appointed managing director of Henry Meadows, Ltd., Wolverhampton.

MR. J. E. PRICE, A.M.I.E.E., has been elected a director of Malcolm and Allan (London), Ltd., an associate of Lancashire Dynamo and Crypto (Mfg.), Ltd.

MR. R. W. ELL has been appointed contracts manager of the Foster switchgear division of Crypton Equipment, Ltd., 1, Victoria Street, London, S.W.1.

MAJOR S. J. J. VAUGHTON, M.C., has been appointed assistant managing director of Higgs Motors, Ltd., Witton, Birmingham. He has been in the company's service for twenty-six years, as sales engineer, sales manager and director.

LONDON TRANSPORT announces the appointment of Mr. L. E. Hawkins, A.C.G.I., M.I.C.E., as assistant civil engineer (structures) with responsibility for the maintenance of all buildings, bridges, structures and earthworks and for the design and erection of bridge and structural work.

SISSONS BROTHERS AND CO., LTD., Hull, announces that an arrangement has been made with Reed, Millican and Co., Ltd., of Newcastle upon Tyne and Carlisle, whereby the mutual paint distributing interests throughout the north of England and south of Scotland are amalgamated under a Sissons subsidiary company, to be known as Sissons Paints (Northern), Ltd. Major H. J. M. Millican and Mr. Keith Millican have been appointed directors of the latter company. Reed, Millican and Co., Ltd., will continue its glass business as at present.

Contracts

BALFOUR, BEATTY AND CO., LTD., has been awarded the first contract, amounting to approximately £6,000,000, for the construction of the Wadi Tharthar project in Iraq. This project, which is for flood relief of the River Tigris at Samara, is to divert the flood waters into the Wadi Tharthar depression, and the first contract consists of the construction of a canal 64km in length. Messrs. Coode, Vaughan-Lee, Frank and Gwyther are the consulting engineers.

DAVY AND UNITED ENGINEERING COMPANY, Ltd., Sheffield, has secured a further large order for rolling mill equipment from the Norwegian Steel Company, A/S Norsk Jernverk. This order for a Morgan combination merchant bar, wire rod and strip mill brings the total value of business now being handled by the firm for A/S Norsk Jernverk to over £2,000,000. The Morgan mill plant will be complementary to the Davy-United blooming, slabbing and section mill plant ordered by A/S Norsk Jernverk fourteen months ago and will be installed as an essential additional part of the new integrated iron and steel works now being established in Northern Norway at Mo i Rana, 25 miles south of the Arctic Circle.

British Patent Specifications

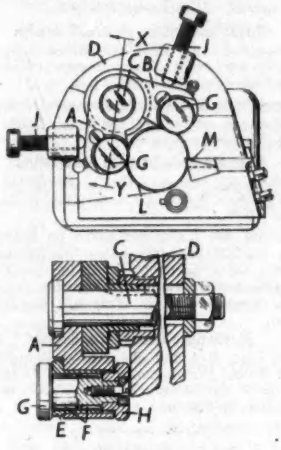
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

MACHINE TOOLS

657,719. February 14, 1949.—Box Tool for a Lathe, Alfred Herbert, Ltd., Canal Road, Foleshill, Coventry, Warwickshire (*Inventor: Harry Treadwell*).

In the case of a long workpiece, and particularly when very high cutting speeds are involved, it is known that there is a tendency for vibrations to be set up in the overhanging end of the workpiece, which not only cause the surface of the workpiece to be unevenly cut or damaged by the tool, but in some cases tend to damage the lathe itself. By the invention this disadvantage is avoided in a very simple manner—by incorporating in the



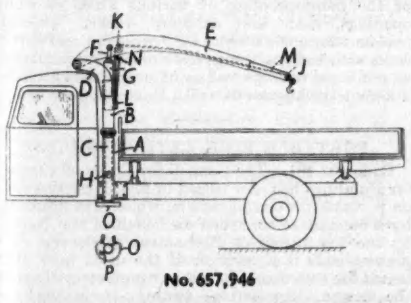
No. 657,719

box tool, instead of each steady roller, a pair of coaxial steady rollers, each of which can engage the machined portion of the workpiece. Two arms, *A* and *B*, pivotally mounted upon a pin *C*, are carried by the body *D* of the box tool. As shown in the section *X*, *Y*, each arm is fitted with a bush *E* in which is journalled on needle rollers *F* the shaft of the main steady roller *G*, the secondary coaxial roller *H* being secured to the end of the shaft by means of a washer and screw. Adjustable backing screws *J* support the arms *A* and *B* with the pairs of coaxial steady rollers *G* and *H* substantially tangential to the opening *L* in the body for the workpiece. *M* indicates a cutting tool. Experiments have shown that these secondary rollers serve satisfactorily, in place of a bush, to prevent trouble arising from vibrations in an overhanging workpiece.—*September* 26, 1951.

ROAD TRANSPORT

657,946. June 10, 1949.—Hydraulic Crane for Motor Vehicles, Fabriks Aktiebolaget Forslund and Co., N. Järnvägsgatan 52, Skelleftea, Sweden.

Referring to the drawing, a tubular pedestal *A* is fixed, immediately behind the driver's cab, to the frame of a motor lorry. The pedestal has a collar on which rests a hydraulic cylinder *B*,



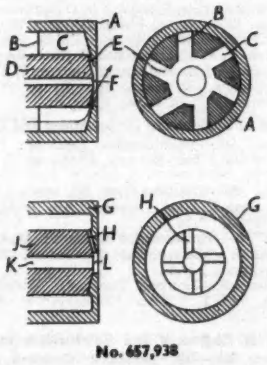
No. 657,946

of which an extension *C* projects through the pedestal. To the upper portion of the cylinder there is welded a bracket *D* on which a cantilever arm *E* is hinged. For the movement of the arm a link *F* is pivotally secured to the arm and to the upper end of a piston *G* in the cylinder. Pressure fluid is introduced into and discharged from the lower end of the cylinder by means of a conduit connected to a control valve *H* on the pedestal. The cantilever arm is composed of two plates, and in an inner space at the outer end of the arm is mounted a pulley or sheave *J*; adjacent to the link *F* there is another pulley *K*. A similar pulley *L* is mounted on the cylinder. These pulleys act as guiding and supporting means for a hoist cable *M*. The inner end of the hoist cable is secured to a hook *N* fixed to the cantilever arm. From the hook the hoist cable extends downwards to the pulley *L* from which it is carried up to the pulley *K*, and on over the pulley *J* to a swivel hook. The means for turning the cylinder about its axis is shown in the lower view. The extension of the cylinder projects into a housing *O* in which a horizontal section has the form of a sector of a circle. To this extension there is secured a partition *P* closely abutting radially against the walls of the inner space of the housing. The partition may be moved round in the housing by pressure fluid.—*September* 25, 1951.

GAS TURBINES

657,938.—May 27, 1949.—Atomising Fluid Fuel by Air in Combustion Chambers, Maschinenfabrik Oerlikon, of Oerlikon, near Zürich, Switzerland.

In the design shown in the upper two drawings, the air nozzle is constituted by a housing *A* carrying segments *B* which form an annular cylinder with passages *C* lying between them. The passages have cross-sectional middle lines lying eccentrically in relation to the central axis of the fuel jet. The axes of the air supply passages may run either parallel to the nozzle axis or at an angle to it. The fuel nozzle *D* forms, first, the inner boundary of the air passages *C*, and, secondly, together with the air nozzle *A*, an annular space *E* having conical walls. In the centre of the



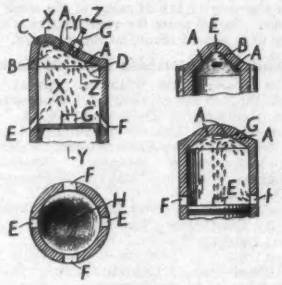
No. 657,938

fuel nozzle is the fuel supply passage *F*. The air flow follows the arrow shown in the drawing, and leads first along the axis of the air supply passages *C*; it then bends round and leads in the direction of the eccentrically situated cross-sectional middle line through the conical annular space *E* towards the fuel outlet *F*. The air is thus split up into individual part streams by the passages *C* before it passes into the annular space *E*. In the modification shown in the lower two views, the air is split up within that portion of the flow path which lies between the conical walls. A housing *G* carries the outer boundary of the conical walls. Air passages *H* are provided in the conical surface of the housing and the fuel nozzle *J* forms the other boundary. The fuel supply passage *K*, with its mouth *L*, lies in the centre of the fuel nozzle *J*. In both designs the passages may be of any desired number adapted to the size of the nozzle.—*September* 26, 1951.

INTERNAL COMBUSTION ENGINES

657,682. February 3, 1948.—Cylinder Heads and Combustion Chambers of Two-Stroke Cycle Internal Combustion Engines, Arthur Cyril Thornton, of "Arrow," Victoria Avenue, The Aerodrome, Yeadon, Near Leeds.

Objects of this invention are to provide a new or improved configuration of combustion chamber resulting in increased power and efficiency, and a combustion chamber in which the best possible conditions of flame propagation are possible, and also one in which carbon deposit and the likelihood of dirty sparking plugs is substantially reduced. Referring to the drawings, these show a cylinder head, also sections on lines *X*, *Y* and *Z*, which has a complex completely curvilinear inner surface and which provides a combustion chamber having convex deflecting side surfaces *A*, a turbulence zone *B*, afforded by a concave recess *C*, and a neutral zone *D* adjacent the cylinder wall. The concave recess or pocket *C* is fully open to the cylinder and is offset from the axis and within the projection of the walls of the cylinder. The main bulk of the mixture is swirled from the convex deflecting surfaces *A* towards and in the concave recess *C* of the combustion chamber forming the turbulence zone *B*, and in the main is then reflected or diverted towards the cylinder bore, thereby enhancing completeness of the scavenging process relative to the circulatory stream. The shape of the convex surfaces *A* together with that of the recess *C* is such that the stream is spread and traverses as



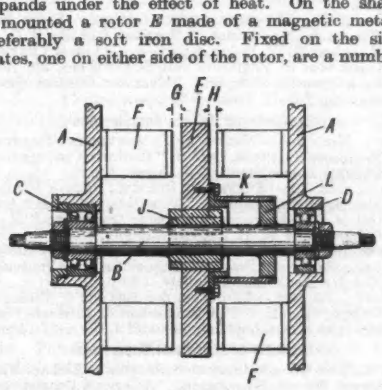
No. 657,682

shown in the drawings, thereby tending to minimise any pocket of burnt gases left from the previous cycle. The cylinder head is arranged in a definite radial position relative to the transfer port or ports *E* and exhaust port or ports *F* as shown in the drawings, so as to provide a circulatory system having the characteristics described. In all cases the sparking plug *G* is positioned at a point between one or more of the convex surfaces *A* and the concave recess or pocket *C* adjacent the turbulence zone *B*, but not in the area of the neutral zone *D*, and always near the direction of the swirl of the main charge from the convex to the concave surfaces to maintain the points clear and free from fouling up.—*September* 26, 1951.

ELECTRICAL ENGINEERING

656,308. December 15, 1948.—Electric Brakes for Automobile Vehicles, Electro-Mecanique de L'Aveyron, of Route de Séverac, Rodez (Aveyron), France.

The invention relates to electric brakes, in which a rotor, preferably of a magnetic metal, rotationally rigid with a shaft to be braked, revolves in the magnetic field of electromagnets, the eddy currents thus created in this rotor producing a braking effect. The brake, as shown in the drawing, includes a frame constituted by two side plates *A* connected together by a cylindrical wall, these side plates acting as a support for a shaft *B*, only one of the ends of which is fixed in the axial direction. The thrust bearing *C* is fixed in one side plate, while the other bearing *D* can slide in the side plate, by which it is supported when the shaft expands under the effect of heat. On the shaft is mounted a rotor *E* made of a magnetic metal, preferably a soft iron disc. Fixed on the side plates, one on either side of the rotor, are a number



No. 656,308

of electromagnets *F*, the polarities of which are such that they create, inside the rotor, when energised by an electric current, eddy currents which exert an efficient braking action upon the rotor *E*. The eddy currents cause an intensive heating of the rotor and the shaft. The shaft therefore expands and the expansion causes a variation in the values of the air gaps *G* and *H*. In order to remedy this disadvantage, according to the invention, the rotor can slide axially with respect to the shaft, while remaining rotationally rigid with it. Interposed between the rotor and the shaft, is a ribbed sleeve *J*, rigid with the shaft, whereby the rotor can be moved in a direction parallel to the sleeve. The rotor is also fitted with compensating means acting in response to thermal expansion when the brake is heated, to produce relative axial displacements of the rotor with respect to the shaft, so that during the period of heating a device keeps air gaps *G* and *H* at substantially constant values. This device may take the form of a sleeve *K* coaxial with the shaft, the end of the sleeve being opposed to the rotor by being fixed to an annular disc *L*, fixed to shaft.—*August* 22, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME AND PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., Nov. 5th.—LEEDS BRANCH: Great Northern Hotel, Wellington Street, Leeds, 1, "Electromechanical Aids to Radiological Technique," E. D. Ormerod, 7.30 p.m.——N.E. LONDON BRANCH: Angel Hotel, Ilford, "General Motor Control Gear," S. H. Harding, 8 p.m.——SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "Electric Discharge Lamps," A. E. Bird, 7.30 p.m.

Tues., Nov. 6th.—W. LONDON BRANCH: Windsor Castle Hotel, 134, King Street, Hammersmith, W.6, "Review of Soviet Industry To-day," 7.30 p.m.

Wed., Nov. 7th.—N. LONDON: The Jolly Butcher's Hotel, Wood Green, London, N.22, "Modern Lift Practice," W. A. Dixie, 8.15 p.m.——YORK BRANCH: Feasgate Restaurant, Feasgate, York, "Flameproof Fittings," J. H. Mollan, 7.30 p.m.

Thurs., Nov. 8th.—BRISTOL BRANCH: Grand Hotel, Bristol, "Fluorescent Lighting and the Maintenance Engineer," A. G. Mitchell, 7.30 p.m.

Fri., Nov. 9th.—CREWE BRANCH: Crewe Arms Hotel, Crewe, "Electric Welding," W. Barnett, 7.30 p.m.——NOTTINGHAM BRANCH: Electricity Showrooms, Smithy Row, Nottingham, "Estimating," W. Brooks, 7.30 p.m.

Birmingham Association of Mechanical Engineers

To-day, Nov. 2nd.—James Watt Memorial Institute, Great Charles Street, Birmingham, "Modern Woodworking Machinery," John Franey, 7 p.m.

British Institution of Radio Engineers

Tues., Nov. 6th.—SCOTTISH SECTION: University College, Dundee, "The Brain as a Piece of Communication Equipment," H. W. Shipton, 7 p.m.

Wed., Nov. 7th.—SCOTTISH SECTION: The University, Edinburgh, "The Brain as a Piece of Communication Equipment," H. W. Shipton, 7 p.m.

Thurs., Nov. 8th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Brain as a Piece of Communication Equipment," H. W. Shipton, 7 p.m.

Illuminating Engineering Society

To-day, Nov. 2nd.—STOKE-ON-TRENT GROUP: 31, Kingsway, Stoke-on-Trent, "Stage Lighting," E. Faraday, 6 p.m.

Tues., Nov. 6th.—CARDIFF CENTRE: S. Wales Electricity Board, Cardiff, "Lighting of Departmental Stores," L. E. Gibbs, 5.45 p.m.

Wed., Nov. 7th.—EDINBURGH CENTRE: Lighting and Cleansing Department, 357, High Street, Edinburgh, "Sports Lighting—Indoor and Outdoor," D. E. Beard, 7 p.m.——NEWCASTLE CENTRE: Minor Durham Hall, Oxford Street, Newcastle upon Tyne, 1, "Glass in the Service of Light," A. J. Holland, 6.15 p.m.

Thurs., Nov. 8th.—MANCHESTER CENTRE: Town Hall Extension, Manchester, "Hospital Lighting," D. J. Reed and M. W. Peirce, 6 p.m.——GLASGOW CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Indoor and Outdoor Sports Lighting," D. E. Beard, 6.30 p.m.

Institute of British Foundrymen

Sat., Nov. 3rd.—WALES AND MONMOUTH BRANCH: Engineers' Institute, Cardiff, "Intricate Castings from Durable Loam Moulds," J. Currie, 6 p.m.

Mon., Nov. 5th.—SHEFFIELD BRANCH: Royal Victoria Station Hotel, Sheffield, "The Observation and Control of Dust in Foundry Dressing Operations," R. F. Ottignon and W. B. Lawrie, 7.30 p.m.

Tues., Nov. 6th.—SLOUGH SECTION: High Duty Alloys, Ltd., Slough, "Practical Experiences in Producing Nodular Iron," M. M. Hallett, 7.30 p.m.

Thurs., Nov. 8th.—LINCOLNSHIRE BRANCH: Technical College, Lincoln, "The Production of Intricate Castings from a Durable Loam Mould," J. Currie, 7.15 p.m.

Institute of Industrial Supervisors

Tues., Nov. 6th.—WARRINGTON SECTION: Richard Fairclough School, Warrington, "American Construction Methods," B. P. Rochester, 7 p.m.——KIDDERMINSTER SECTION: Carpet Trades, Ltd., Mill Street, Kidderminster, "Atomic Energy," J. H. Fremlin, 7.30 p.m.

Wed., Nov. 7th.—BIRMINGHAM SECTION: College of Technology, Suffolk Street, Birmingham, "Shop Management's Contribution to Increased Efficiency," J. R. Immer, 7.30 p.m.

Thurs., Nov. 8th.—LEEDS SECTION: Great Northern Hotel, Leeds, "Motion Study on the Shop Floor," T. Gardiner, 7.30 p.m.——SMETHWICK SECTION: Chance Technical College, Crocketts Lane, Smethwick, Members' Discussion Night, "Equal Pay for Men and Women," 7.30 p.m.——N.W. SECTION: Technical College, Hyde, "The Foreman and the Factories Acts," J. B. Hopgood, 7.30 p.m.

Institute of Metals

Tues., Nov. 6th.—S. WALES LOCAL SECTION: University College, Metallurgy Department, Singleton Park, Swansea, "Pressing and Sintering of Metal Powders," J. C. Chaston, 6.30 p.m.

Thurs., Nov. 8th.—LONDON LOCAL SECTION: Royal School of Mines, South Kensington, S.W.7, "Transformations in Metals," C. S. Barrett, 7 p.m.

Institute of Physics

To-day and Sat., Nov. 2nd and 3rd.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, Autumn Conference, 1951, "The Structures of Silicate Minerals." Fri., "Calcium Silicates," 2.15 p.m., "Felspars," W. H. Taylor, 8.30 p.m.; Sat., "Clay Minerals and Asbestos," 9.45 a.m.

Institute of Road Transport Engineers

Mon., Nov. 5th.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Pistons, Rings and Cylinder Liners," G. W. Yarwood, 7.30 p.m.

Tues., Nov. 6th.—EASTERN GROUP: Marshalls Airport, Cambridge, "Vacuum and Air Brakes," S. H. Edge, 7 p.m.

Institution of Chemical Engineers

Tues., Nov. 6th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Part III: The Mechanism of the Drying of Solids with special reference to China Clay," D. M. Newitt and M. Coleman, 5.30 p.m.

Institution of Civil Engineers

Thurs., Nov. 8th.—MIDLANDS ASSOCIATION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Water Supply," Norman J. Pugh, 6 p.m.——N.W. ASSOCIATION: Engineers' Club, Albert Square, Manchester, "Prestressed Concrete Bridges and Liquid Retaining Structures," J. W. A. Ager, 6.30 p.m.

Institution of Electrical Engineers

Sat., Nov. 3rd.—N. MIDLAND STUDENTS' SECTION: Yorkshire Electricity Board Offices, Market Street, Huddersfield, "The A.C. Traction Motor," G. M. Nixson, 2.30 p.m.

Mon., Nov. 5th.—S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Economic Plant Sizes and Boiler-Set Groupings on the British Grid," B. Donkin and P. H. Margen, 6 p.m.——LONDON STUDENTS' SECTION: Savoy Place, W.C.2, "Power Station Practice, with particular reference to Earley Power Station," J. E. G. Silvester and M. G. Nash, 7 p.m.

Tues., Nov. 6th.—MEASUREMENTS SECTION: Savoy Place, London, W.C.2, Discussion on "Measurements Involved in the Testing of Protective Equipment." Opened by H. S. Petch, 5.30 p.m.——SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Planning of an Electricity Board's Distribution System," G. O. McLean, 7 p.m.

Wed., Nov. 7th.—SCOTTISH CENTRE: Heriot-Watt College, Edinburgh, "The Planning of an Electricity Board's Distribution System," G. O. McLean, 7 p.m.

Thurs., Nov. 8th.—Savoy Place, London, W.C.2, "The London-Birmingham Television-Cable System," T. Kilvington, F. J. M. Laver and H. Stanesby, 5.30 p.m.

Fri., Nov. 9th.—N.E. STUDENTS' SECTION: Grey Hall, King's College, Newcastle upon Tyne, "Electronic Motor Control," C. R. Bates, 6.30 p.m.

Institution of Engineering Draughtsmen and Designers

Mon., Nov. 5th.—GLOUCESTER BRANCH: Imperial Hotel, Stroud, Glos., Meeting, Chairman L. B. Stone, 7 p.m.

Tues., Nov. 6th.—GLOUCESTER BRANCH: Technical College, Stroud, Glos., Films, "Arc Welding," and "Hard Metal," 7.15 p.m.

Wed., Nov. 7th.—BIRMINGHAM BRANCH: Queens Hotel, Birmingham, "Design for Mechanical Handling," S. R. Cadman, 7 p.m.

Thurs., Nov. 8th.—LONDON BRANCH: Waldorf Hotel, Aldwych, W.C.2, "Naval Gunnery," P. J. Booker, 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tues., Nov. 6th.—39, Elmbank Crescent, Glasgow, "Some Aspects of Research in Friction and Wear," F. T. Barwell, 6.30 p.m.

Institution of Mechanical Engineers

To-day, Nov. 2nd.—Storey's Gate, St. James's Park, S.W.1, "Some Factors Affecting Wear on Cemented Carbide Tools," E. M. Trent, 5.30 p.m.——N.E. BRANCH: Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, "Everyday Engineering," J. E. White, 7 p.m.

Mon., Nov. 5th.—N.E. BRANCH: Stephenson Building, Claremont Road, Newcastle upon Tyne, "Engineering Laboratories, King's College, University of Durham," A. F. Burstall, 6 p.m.

Tues., Nov. 6th.—COVENTRY A.D. CENTRE: Craven Arms Hotel, High Street, Coventry, "Experiences During Twenty Years of Oil Engine Development," C. B. Dicksee, 7 p.m.

Wed., Nov. 7th.—SOUTHERN BRANCH: Municipal College, Portsmouth, Film, "The Raising of H.M. Submarine 'Truculent,'" 7 p.m.

Thurs., Nov. 8th.—N.W. BRANCH, GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, "Turbine Blading," T. L. R. S. Dickin, 6.45 p.m.——SCOTTISH BRANCH: Royal Technical College, Glasgow, Presidential Address, A. C. Hartley, 7.30 p.m.——WESTERN A.D. CENTRE: Park Hotel, Cardiff, "Some Factors Governing the Performance of Crankcase Lubricating Oils," A. Towle, 6.45 p.m.

Fri., Nov. 9th.—Storey's Gate, St. James's Park, London, S.W.1, "The Design of Large Pumping Installations for Low and Medium Heads," G. A. Wauchope and H. P. Humphreys, 5.30 p.m.——SCOTTISH BRANCH: North British Station Hotel, Edinburgh, Presidential Address, A. C. Hartley, 7.30 p.m.

Institution of Production Engineers

Tues., Nov. 6th.—HALIFAX SECTION: George Hotel, Huddersfield, "The Production of Steel and Bronze Castings for Engineering Purposes," G. L. Hancock, 7.15 p.m.——READING SECTION: Great Western Hotel, Reading, "Mechanical Handling," F. T. Dean, 7.15 p.m.

Wed., Nov. 7th.—LIVERPOOL SECTION: Radiant House, Bold Street, Liverpool, "Accident and Accident Prevention," C. P. Gourley, 7.15 p.m.——LUTON GRADUATE SECTION: St. Albans Court House, Luton, "Developments in Centreless Grinding Technique," A. Scrivener, 7.30 p.m.——NOTTINGHAM SECTION: Victoria Station Hotel, Milton Street, Nottingham, "The Lost Wax Process," A. Short, 7 p.m.

Institution of Structural Engineers

Tues., Nov. 6th.—NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Contrast and Similarities between Ship and Land Structures," G. M. Boyd, 6.30 p.m.——N. IRELAND BRANCH: College of Technology, Belfast, "The Use of Equal Strength Principles in the Design of Structures for Minimum Weight," R. M. Kenedi, 7.30 p.m.

Junior Institution of Engineers

To-day, Nov. 2nd.—39, Victoria Street, London, S.W.1, Film Evening, "Concrete"; "Moving Earth," introduced by H. E. Hodgson, 6.30 p.m.

Mon., Nov. 5th.—N.W. SECTION: Manchester Geographical Society, 16, St. Mary's Parsonage, Manchester, "Modern Electric Traction," J. K. Brown, 7.30 p.m.

Fri., Nov. 9th.—39, Victoria Street, London, S.W.1, "The Engineer and Safety," F. M. Panzetta, 6.30 p.m.

Liverpool Metallurgical Society

Fri., Nov. 9th.—Electricity Service Centre, Whitechapel, Liverpool, "What is a Dislocation," B. A. Bilby, 7 p.m.

Manchester Association of Engineers

To-day, Nov. 2nd.—Engineers' Club, Albert Square, Manchester, "Modern Methods of Sound Reproduction," J. R. G. Vernon, 6.45 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Fri., Nov. 9th.—Literary and Philosophical Society, Newcastle upon Tyne, 1, "Shortcomings of Structural Analysis," J. F. Baker, 6.15 p.m.

Royal Institution of Great Britain

To-day, Nov. 2nd.—21, Albemarle Street, London, W.1, "Experiments with High Energy Nucleons and Quanta," Sir John Cockcroft, 9 p.m.

Sheet and Strip Metal Users Technical Association

To-day, Nov. 2nd.—Charing Cross Hotel, London, W.C.2, Annual Winter Conference.

Sheffield Metallurgical Association

Tues., Nov. 6th.—Grand Hotel, Sheffield, "Radio Chemistry as an Aid to the Analytical Chemist," A. A. Smales, 7 p.m.

Societe des Ingenieurs Civils de France

Fri., Nov. 9th.—BRITISH SECTION: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Development of Hydraulic Power Production and High Tension Transmission in France," R. Brongniart, 5.30 p.m.

Stephenson Locomotive Society

To-day and Sat., Nov. 2nd and 3rd.—Midland Institute, Ratcliff Place, Birmingham, Midland Centre's Fifth Anniversary Exhibition, To-day, 6 p.m. to 9 p.m. Sat., 11 a.m. to 6 p.m.

Codes of Practice

The Codes of Practice Committee for Civil Engineering, Public Works and Building and Constructional Work is under the aegis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

DENSE CONCRETE WALLS

Code 123.101, "Dense Concrete Walls," which was prepared by a committee convened by the Royal Institute of British Architects on behalf of the Council for Codes of Practice for Buildings, has now been issued in final form. It should be read in conjunction with Code 111, "Structural Recommendations for Loadbearing Walls," and Code 111.201, "Concrete Cast In-Situ." It deals with the construction of solid and cavity walls of dense concrete (as distinct from lightweight or no-fines concrete), both plain and reinforced. Recommendations are made regarding the type and quality of materials, the proportioning and mixing of the concrete and the control of shrinkage. The provision of expansion joints, to avoid failures arising from thermal movement, is dealt with and details for typical joints in walls are illustrated. Full information is given on surface finishes and damp-proof courses and detailed recommendations are made in respect of setting out, scaffolding and formwork on site. The Code includes illustrations of the damp-proofing of various kinds of walls, openings, roofs and chimney stacks. Thermal transmittance coefficients for both solid and cavity walls with various linings and finishes are tabulated, as are some average values of sound reduction for different thicknesses of wall. Price 4s., post free.

PORTABLE FIRE EXTINGUISHERS

Code 402.401. The Council for Codes of Practice for Buildings has now issued in final form this code on portable fire extinguishers, which was drawn up by a committee convened on behalf of the Council by the Institution of Mechanical Engineers. The present code is a revision of the draft previously issued for comment. It makes recommendations on the design, installation, testing, inspection and maintenance of portable fire-fighting appliances for general use in buildings. The appliances dealt with are portable extinguishers, fire buckets and portable pumps, such as can be readily carried by one person.

The code carries the usual warning that, in the present abnormal conditions, it may not be practicable to carry out all the recommendations. Price 2s. post free.